Covert Reminders: The Use of Distraction to Enhance Memory in Older Adults

by

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Abstract

Aging is associated with difficulty down-regulating attention to distraction and increased forgetting in explicit memory tests. This thesis explored whether older adults’ distractibility can counterintuitively boost memory when presentations of distraction provide an opportunity for memory-strengthening rehearsal between learning and a delayed memory test. Four studies used the same general procedure: Younger and older participants studied and recalled a list of words on an initial test and again on a surprise test following a 15-min delay. During the delay, participants completed a 1-back task in which half of the studied words appeared as distractors.

The first two studies examined whether repeating studied words as distraction midway through (Study 1a) or at the end of a delay interval (Study 2) would reduce forgetting for older, but not younger adults, who previous research has shown can effectively ignore distraction. Studies 3a and 3b explored whether younger and older adults can retroactively take advantage of rehearsal opportunities presented as distraction when directly instructed about their relevance at retrieval. Finally, Study 4 explored whether positive and neutral moods, which are known to affect attentional control abilities, influence the costs and benefits of distraction as a rehearsal device in younger adults.
Results indicated that repeating to-be-remembered words as distraction minimized (Study 1a) or eliminated (Studies 2, 3b) older adults’ forgetting, consistently resulting in final recall that was equivalent to younger adults’ recall. Repeating words as distraction did modulate younger adults’ recall by increasing forgetting of unrepeated words when they were directly cued about the repetitions (Study 3a), and by increasing forgetting of repeated words under induced neutral moods (Study 4). Nonetheless, younger adults showed clear forgetting of repeated words across all experiments. These results demonstrate that distraction can serve as covert reminders for older adults, a finding with implications for the reduction of prevalent age differences in explicit memory performance.
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Chapter 1: Introduction

Psychological research has few laws, but a law of memory about which there is little dispute is that repetition strengthens memory and protects against forgetting. That is, material that is repeatedly reflected on or rehearsed, especially in a distributed manner across time, is more likely to be remembered than information that is only processed once (e.g., Crowder, 1976; Ebbinghaus, 1885/1964; Greene, 2008; James, 1890). Benefiting from repetition is adaptive, since items or facts encountered and rehearsed numerous times in the past, especially at widely spaced intervals, are likely to become important again (J. R. Anderson & Schooler, 1991). The predictive value of repetitions means that they profoundly influence everyday remembering in familiar environments. For example, repeated opportunities to dial a friend’s new phone number, or reading and rehearsing the name of a new medication while taking a pill can diminish forgetting of this information.

Past research on repetition has been limited to target information, that is, attended information that is goal-relevant according to the demands of the current task. However, in their everyday environments, individuals encounter a diverse range of information, both relevant and irrelevant to their current goals. Can goal-irrelevant distraction also serve as a source of repeated study or rehearsal? While the answer to this question is unknown, inhibitory theory suggests that it may depend on one’s ability to filter out distracting information. Typically in real-life tasks, efficient performance requires irrelevant or peripheral information to be inhibited in order to focus on the task at hand (Hasher, Lustig, & Zacks, 2007; Hasher, Zacks, & May, 1999). Thus, when inhibitory mechanisms are operating effectively, distraction, whether it incorporates repeated information or not, should be ignored and therefore have no influence on subsequent memory. However, the efficiency of inhibitory mechanisms varies both within (e.g., according to
one’s current mood) and across individuals (e.g., according to one’s age). In particular, older adults have more difficulty suppressing the processing of goal-irrelevant information than do younger adults (Hasher et al., 2007, 1999; Hasher & Zacks, 1988; see also Rabbitt, 1965). This observation leads to the novel prediction that reduced suppression of goal-irrelevant information may allow distraction to serve as a unique source of memory-strengthening rehearsals for older adults.

The possibility that distraction can help older adults to incidentally rehearse information may have important implications for remediating typical age-related forgetting. Aging is associated with decreased performance on long-term memory tasks requiring conscious, deliberate recollection of previously learned information (for reviews see Balota, Dolan, & Duchek, 2000; Grady & Craik, 2000; Zacks & Hasher, 2006). In particular, older adults show greater forgetting than younger adults when few cues are provided at retrieval, as in tests of free recall (Craik & McDowd, 1987; La Voie & Light, 1994), and when recollection of associative or contextual information is required (Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000; Spencer & Raz, 1995). However, by uniquely strengthening older adults’ memory, repeated study or rehearsal opportunities of information that occurs as distraction may counteract age-related forgetting in these retrieval situations.

As mentioned above, inhibitory control can also vary within an individual, for example, according to one’s emotional state. More specifically, positive moods are thought to broaden attention towards distraction, while neutral and negative moods tend to enhance inhibitory control (Derryberry & Tucker, 1994; Fredrickson, 1998; Rowe, Hirsh, & Anderson, 2007). Given this influence of mood on the processing of distraction, it is possible that affective state, like aging, could influence whether individuals are able to benefit from presentations of distraction that can function as a rehearsal opportunity. That is, greater distractibility for younger
adults under positive affect might allow them to also take advantage of distraction as a rehearsal device, while more negative or neutral moods may sharpen already-efficient inhibitory control.

Here, I explore the prediction that older adults’ increased distractibility can allow them to take advantage of a source of rehearsals that younger adults typically ignore, thereby reducing age-related memory deficits that are otherwise prevalent in the cognitive aging literature. I also investigate whether inducing a positive mood in younger adults can allow them to similarly benefit from distraction as rehearsals. These predictions are based on three lines of evidence, each considered in turn. First, I review evidence for younger adults’ general proficiency at ignoring distraction, and briefly discuss how mood may modulate their inhibitory control abilities. I examine evidence suggesting that age-related declines in inhibitory control increase older adults’ susceptibility to distraction, as well as research showing that older adults tacitly transfer knowledge of distraction to boost performance on subsequent tasks. Second, I discuss how implicit transfer of distraction reflects preserved implicit or automatic memory systems that can support older adults’ remembering. Third, I discuss the conditions required for repeated presentations of memoranda to effectively improve memory in younger and older adults. In the remainder of this thesis, I report four studies collectively demonstrating that repeating to-be-remembered information as distraction can implicitly boost older adults’ recall, while providing little advantage to younger adults.

Inhibitory Control and Aging

As everyday life is filled with information that is irrelevant to one’s current goals, many daily tasks require focused attention on target information and suppression of potentially interfering distractors. Models of attention propose that top-down biasing signals from the prefrontal cortex gate perceptual and cognitive inputs to ensure that only information relevant to
one’s internal goals is elaboratively processed and permitted to guide behaviour (Desimone & Duncan, 1995; Miller & Cohen, 2001). Healthy young people tend to be very skilled at engaging inhibitory control to both limit the entrance of distraction into working memory and dampen activation if it does gain access (Hasher et al., 2007, 1999; Lavie, 2005, 2010). For example, younger adults inhibit processing of distracting objects, so that these objects minimally influence task performance even relative to passively-presented background information (Wühr & Frings, 2008). In some cases, younger adults’ attentional control over distraction is so effective that they show “inattentional blindness” for task-irrelevant information (e.g., Mack & Rock, 1998):
Younger adults are able to ignore centrally-presented distracting words to the extent that their neural activity does not distinguish these words from random letters (Rees, Russell, Frith, & Driver, 1999).

The ability to suppress irrelevant information varies across individuals, and is considered central to higher cognitive functions, such as working and long-term memory (Hasher et al., 2007; Kane, Conway, Hambrick, & Engle, 2007; Vogel, McCollough, & Machizawa, 2005). Inefficient filtering of distraction results in a more cluttered mental workspace, in which irrelevant information from the past or present can compete with the processing of goal-relevant information. Inhibitory efficiency is known to vary according to different mental states within an individual, including as a function of one’s mood (e.g., Biss & Hasher, 2011; Rowe, Hirsh, & Anderson, 2007) or circadian arousal level (e.g., May & Hasher, 1998; May, 1999; Rowe, Valderrama, Hasher, & Lenartowicz, 2006). For example, while younger adults are typically proficient at ignoring irrelevant information, positive mood increases their susceptibility to distraction on a range of attention tests (Dreisbach & Goschke, 2004; Fenske & Eastwood, 2003; Goeleven, De Raedt, & Koster, 2007; Phillips, Bull, Adams, & Fraser, 2002; Rowe et al., 2007), and is even associated with greater tacit knowledge of distraction later on (Biss, Hasher, &
Thomas, 2010; Biss & Hasher, 2011). Positive affect is also associated with sustained memory for no-longer-relevant information, whereas this information is more readily suppressed under negative and neutral moods (Bäuml & Kuhbandner, 2009).

Attentional control mechanisms appear to be particularly impaired in older adults, a disruption which may be a crucial contributor to age differences in memory performance (Hasher et al., 1999; Hasher & Zacks, 1988). In support of an age-related deficit specific to the suppression of irrelevant information, older adults show increased neural encoding of visual distraction, while enhancement of goal-relevant targets is age-invariant (Gazzaley et al., 2008; Gazzaley, Cooney, Rissman, & D’Esposito, 2005). This increased processing of irrelevant information is associated with reduced recruitment of frontoparietal regions that control attention (Campbell, Grady, Ng, & Hasher, 2012; Gutches et al., 2007; K. J. Mitchell, Ankudowich, Durbin, Greene, & Johnson, 2013).

The consequences of reduced inhibitory control are apparent when older adults perform target tasks in the presence of irrelevant distraction. Visual distraction disrupts older adults’ performance relative to that of younger adults on a wide range of tasks, including those assessing reading (Connelly, Hasher, & Zacks, 1991; Darowski, Helder, Zacks, Hasher, & Hambrick, 2008; Duchek, Balota, & Thessing, 1998), perceptual speed (Lustig, Hasher, & Tonev, 2006; Rabbitt, 1965), and problem solving (May, 1999). While the pattern of age differences is more complicated when processing of auditory or cross-modal distraction is tested (Guerreiro, Murphy, & Van Gerven, 2010), studies using neural measures clearly indicate that older adults are also less able than their younger counterparts to suppress auditory distraction (Alain & Woods, 1999; Chao & Knight, 1997; Fabiani, Low, Wee, Sable, & Gratton, 2006; Stevens, Hasher, Chiew, & Grady, 2008). Thus, evidence across different experimental measures and
sensory domains supports a specific deficit for older adults in the inhibition of concurrent
distraction.

A second consequence of reduced inhibitory efficiency is that older adults carry forward
once-relevant information from the past that younger adults have already deleted (Hasher et al.,
1999). For example, older, but not younger adults continue to maintain old interpretations of a
text that are no longer contextually relevant (Hamm & Hasher, 1992), and have sustained access
to previously-generated, but no longer relevant sentence endings (May & Hasher, 1998).
Moreover, older adults are more vulnerable to the accumulation of interference from prior
learning on various working memory (e.g., Bowles & Salthouse, 2003; Lustig, May, & Hasher,
2001; Rowe, Hasher, & Turcotte, 2008; Zeintl & Kliegel, 2010), associative learning (e.g., Ebert
& Anderson, 2009; Kliegl & Lindenberger, 1993; Winocur & Moscovitch, 1983), and even
implicit memory tasks (Ikier & Hasher, 2006; Ikier, Yang, & Hasher, 2008). This evidence
indicates that older adults’ performance is not only disrupted by concurrent distraction, they also
experience disproportionate interference from no-longer-relevant information from the recent
past.

Given that older adults both encode never-relevant distraction and show sustained access
to past information that is no longer relevant, one might predict that older adults also carry
forward previously distracting information to new tasks. Evidence suggests that older adults
indeed transfer knowledge of distraction, such that their cognitive performance benefits when
previously irrelevant information subsequently becomes useful (Healey, Campbell, & Hasher,
2008). Older adults outperform younger adults on tacit or implicit tasks that tap perceptual
(Rowe et al., 2006) and conceptual (Amer, 2012; Kim, Hasher, & Zacks, 2007) knowledge of
past distraction, as well as knowledge of statistical regularities among distracting events
(Campbell, Zimerman, Healey, Lee, & Hasher, 2012). For example, Rowe and colleagues (2006)
had younger and older adults perform a 1-back task on pictures that were superimposed with distracting words or nonwords. Participants were instructed to press a key whenever consecutive pictures were identical, and to ignore the superimposed words or nonwords. When implicit memory was tested using a word fragment completion task after a 10 min delay, older adults showed greater priming for the previously distracting words compared to younger adults. Thus, older adults show downstream effects of distractibility when past distraction can facilitate subsequent task performance.

Older adults also implicitly transfer knowledge of irrelevant information to benefit memory on new, intentional learning tasks. In a study by Thomas and Hasher (2012), older and younger adults learned a memory list, which included words that had previously been presented as distraction in another task. Older, but not younger, adults had better recall of these previously distracting words compared to completely new words. Similarly, when former targets and co-occurring distractors reappeared as to-be-remembered pairs on a new associative memory task, older adults had enhanced memory for these preserved pairs relative to new pairs (Campbell, Hasher, & Thomas, 2010). Previous distraction can also interfere with new learning if it instead competes with, rather than supports retrieval of currently relevant information. For example, Campbell and colleagues (2010) found that older adults’ cued recall of previously studied but rearranged target-distractor pairs was disrupted relative to new pairs. Likewise, when old picture cues that had previously occurred with distraction were included in a studied list of picture-word pairs, older adults’ memory performance was disrupted across the entire list (Biss, Campbell, & Hasher, 2013).

These costs and benefits for older adults represent implicit effects on explicit memory performance: In each study, participants were unaware about the connection between tasks. In contrast, younger adults do not implicitly transfer previous distraction, although they sometimes
use this knowledge if explicitly cued about the connection between tasks (Dywan & Murphy, 1996; Gopie, Craik, & Hasher, 2011; Kemper & McDowd, 2006; Thomas & Hasher, 2012; but see Campbell et al., 2010; Rees et al., 1999). Thus, past work demonstrates that, in addition to their increased susceptibility to concurrent distraction, older adults show sustained knowledge of distraction, which can improve (and sometimes disrupt) learning on later memory tests. Moreover, this effect is unique to older adults when transfer is implicit.

**Implicit Memory and Aging**

Older adults’ tendency to tacitly transfer knowledge of previous distraction is consistent with the proposal that automatic memory processes are sustained across the lifespan (Hasher & Zacks, 1979). On various retrieval tasks tapping implicit memory, or memory without explicit or conscious awareness, age differences tend to be small or nonexistent (e.g., La Voie & Light, 1994). For example, younger and older adults show similar levels of priming on tests of word stem or word fragment completion (Jelicic, Craik, & Moscovitch, 1996; Light & Singh, 1987; D. B. Mitchell & Bruss, 2003), category exemplar generation (Light & Albertson, 1989), and picture naming (D. B. Mitchell, Brown, & Murphy, 1990; D. B. Mitchell & Bruss, 2003). Age differences are also minimal on measures of familiarity, a relatively automatic explicit memory process that involves the experience of prior events without recollecting specific associated details of the study episode (e.g., N. D. Anderson et al., 2008; Java, 1996; Jennings & Jacoby, 1997; Light, 2012).

In the context of relative age-related declines in controlled recall and recollection processes (e.g., Balota et al., 2000; Grady & Craik, 2000; Zacks & Hasher, 2006), this generally preserved implicit retrieval can both facilitate and interfere with older adults’ performance on explicit memory tests. This is seen, for example, in process dissociation paradigms when intact
familiarity works in concert with recollection in inclusion conditions or produces competing responses in exclusion conditions (Jacoby, 1991; Jennings & Jacoby, 1997). Similarly, familiar contextual information can both facilitate older adults’ correct recognition of old words and exacerbate false alarms to new words, while having little influence on younger adults’ recognition performance (B. A. Anderson, Jacoby, Thomas, & Balota, 2011; Craik & Schloerscheidt, 2011). Evidence for older adults’ tacit transfer of past distraction to boost new learning on free recall (Thomas & Hasher, 2012) and cued recall (Campbell et al., 2010) tasks also supports the existence of implicit contributions to older adults’ performance on tasks that largely rely on controlled retrieval. Therefore, generally intact implicit memory processes in older adults means that they can disproportionately benefit in situations where tacit retrieval can support conscious and effortful remembering.

Benefits of Repetition

Over a century of research demonstrates that spaced repetitions or rehearsals occurring as relevant, target information reduce forgetting relative to information processed on a single occasion (e.g., Crowder, 1976; Ebbinghaus, 1885/1964; Greene, 2008). For example, repetition is known to improve cued and free recall performance (e.g., Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006), as well as boost estimates of both recollection and familiarity on recognition tests (Jacoby, 1999; Light, Chung, Pendergrass, & Ocker, 2006).

What conditions are required for repetitions and rehearsals to be effective? Evidence from research based on younger adults indicates that attention must be engaged for target repetitions to reduce forgetting: Repeated study opportunities that occur in the absence of attention have negligible effects on memory performance (Greene, 2008; Nickerson & Adams, 1979). Indeed, one explanation for the inadequacy of massed, as compared to distributed
repetitions suggests that a second presentation occurring immediately after the first may not be attended or as thoroughly processed compared to a second occurrence occurring after a longer delay (Hintzman, 1974). In a similar manner, repetitions in the form of simple rote rehearsals are thought to have little influence on long-term memory when tested via free recall (e.g., Craik & Watkins, 1973; Greene, 1987), although rote rehearsal can improve recognition memory in some cases (Davachi, Maril, & Wagner, 2001; Naveh-Benjamin & Jonides, 1984). Thus, unattended repetitions are considered ineffective at boosting subsequent memory and reducing forgetting, particularly when it comes to performance on recall measures.

Age differences in the ability to benefit from repetition depend on whether memoranda are externally reinstated through perception (e.g., repeated study) or are internally reactivated via self-generated reflection (e.g., rehearsals, refreshing; Johnson, 1992). Some evidence suggests that older adults may be less likely to engage internal forms of repetition, as might be predicted from age-related decrements in self-initiated processing (Craik, 1986). For example, age differences are seen in the quality and quantity of self-generated rehearsals when studying a word list: Older adults rehearse fewer unique words and do not strategically distribute rehearsals as broadly throughout the study session as younger adults do (Sanders, Murphy, Schmitt, & Walsh, 1980; Ward & Maylor, 2005). Older adults are also slower to refresh, or immediately reactivate, information that was just presented, and show a smaller mnemonic benefit for refreshed items compared to younger adults (Johnson, Reeder, Raye, & Mitchell, 2002).

In contrast to internally reactivated repetitions, externally reinstated repetitions occurring as goal-relevant study trials decrease forgetting in a similar manner for both younger and older adults (e.g., Balota, Duchek, & Paullin, 1989; Cohen, Sandler, & Schroeder, 1987; Logan & Balota, 2008; Morrow, Leirer, Carver, Tanke, & McNally, 1999). This evidence from research on aging and repetition effects indicates that while older adults are less likely to strategically
initiate rehearsals, they benefit to a similar degree as younger adults from externally-cued repetitions. That is, older adults are equally likely to benefit from opportunities to rehearse or strengthen studied information when the rehearsals are cued by target information in the external environment.

Overview of the Current Research

The research reviewed above suggests that older adults are more likely to attend to irrelevant distraction and carry forward knowledge of previous distraction to subsequent tasks, whether these tasks themselves are implicit or explicit. This tacit transfer of distraction reflects preserved implicit retrieval processes, and stands in contrast to heightened age-related forgetting on retrieval tasks requiring controlled recall of target information. Finally, research with younger adults suggests that repetitions must be attended in order to enhance recall. Older adults are as likely as younger adults to profit from repeated study opportunities for target information; however, they have more difficulty strategically engaging internal rehearsal.

Based on this combined evidence from research on inhibitory control, implicit memory, and repetition of target information, several predictions may be made about the possible use of distraction as a repeated study or rehearsal device. First, given younger adults’ general proficiency at ignoring task-irrelevant information (e.g., Connelly et al., 1991; Gazzaley et al., 2005; May, 1999; Rabbitt, 1965) as well as evidence that attention is required to produce repetition benefits (e.g., Greene, 2008; Nickerson & Adams, 1979), repeating studied items from a memory list as distraction would be expected to have little influence on younger adults’ memory performance. Given evidence that affective states modulate distraction regulation (e.g., Rowe et al., 2007), it is possible that younger adults may be able to benefit from distraction as a rehearsal opportunity when in a positive mood.
In contrast to younger adults’ efficient inhibitory control abilities, older adults both attend to irrelevant distraction and implicitly transfer their knowledge of distraction to subsequent tasks (Campbell et al., 2010; Kim et al., 2007; Rowe et al., 2006; Thomas & Hasher, 2012). Hence, they would be expected to process repetitions that occur as non-target information during the course of an unrelated task, as well as show sustained access to this information later on. In this manner, repetitions of memoranda that are presented as distraction between learning and a final memory test may benefit older adults’ memory performance, while having minimal effect on younger adults. Since implicit retrieval is generally age-invariant (e.g., La Voie & Light, 1994; except when interference is present among materials, Ikier & Hasher, 2006; Ikier et al., 2008) and transfer of distraction by older adults occurs tacitly, this benefit should occur without older adults’ awareness that these repetitions took place. If confirmed, this would provide a method by which older adults’ tendency to process irrelevant information may be co-opted to counteract age-related declines in explicit memory performance.

The four studies described in this thesis addressed the question of whether repeating studied items as distraction during a retention interval would boost memory and reduce forgetting. In the first three studies, I examined whether repeating items as distraction would reduce age-related forgetting in older, but not younger adults, given older adults’ greater susceptibility to distraction. In a fourth study, I examined whether inducing positive and neutral affect would modulate the effect of distraction as a rehearsal device for younger adults. All studies used the same general, three-phase procedure: (1) intentional study and initial recall of a memory list, (2) a 15 min delay interval that included a 1-back task in which some memory list items were repeated as distraction, (3) a final free recall test. The critical outcome measure was
performance on two free recall tests, a task on which older adults are typically disadvantaged relative to younger adults (e.g., Craik & McDowd, 1987).

In the first phase, participants studied a list of 20 words, which included two primacy and two recency buffers, and 16 critical words. Participants were asked to recall the word list after a 30 s delay, with no mention made of a later recall test. The critical task during the second phase was a 1-back task, in which participants saw a rapid stream of pictures and detected whether consecutive pictures were identical (see Biss, Campbell, & Hasher, 2013; Campbell et al., 2010; Rowe et al., 2006). Superimposed on the pictures were irrelevant words or letter strings that participants were instructed to ignore. Unbeknownst to participants, the distraction also included eight of the words from the studied memory list (called repeated words), creating an opportunity for tacit rehearsal of these items. In order to minimize the likelihood that participants would become aware of these repetitions, each repeated word was presented as distraction only twice and trials with these items were randomly intermixed with trials presenting novel words and nonwords as the superimposed distraction. In the third phase of the procedure, memory for the studied word list was tested again in a surprise recall test. Forgetting between initial and final recall was compared between the studied words that repeated as distraction in the 1-back task and the unrepeated words that only appeared on the initial study trial.

In Study 1a, I tested the hypothesis that older, but not younger adults, would show reduced forgetting for items that repeated as distraction between study and a final recall test\(^1\). This hypothesis was indeed confirmed. In order to determine whether a mnemonic boost for repeated words came at the expense of unrepeated words, Study 1b compared older adults’

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\(^1\) The data in Studies 1a, 1b, 2 and 3a/3b (indirect condition) are published in a slightly different format as Biss, Ngo, Hasher, Campbell, & Rowe (2013), Psychological Science, doi: 10.1177/0956797612457386. © The Authors, 2013.
forgetting in Study 1a to a condition in which only novel, unrelated words appeared as
distraction during the retention interval. In Study 2, the goal was to conceptually replicate the
findings of Study 1a, as well as to elucidate whether the timing of the repetition opportunity
influences younger and older adults’ forgetting. In Study 3a, I explored whether younger adults
are able to retroactively take advantage of repetitions presented as distraction when explicitly
instructed at retrieval about the potential relevance of the retention-interval distraction. Study 3b
examined whether these explicit instructions affect the mnemonic benefit for repeated words
among older adults. Finally, Study 4 investigated whether inducing positive affect, which is
known to broaden attention to distraction relative to neutral or negative affect (e.g., Derryberry &
Tucker, 1994; Fredrickson, 1998), would modulate the potential costs and benefits of distraction
as a rehearsal opportunity in younger adults. Thus, the central aim of this series of studies was to
test whether repetitions presented as distraction may serve as covert reminders for older
individuals with reduced inhibitory control, as well as for younger adults when explicitly
instructed about the distraction or when in induced positive moods.
Chapter 2: Age Differences in the Use of Distraction as Rehearsal

Older adults’ reduced ability to down-regulate attention to task-irrelevant distraction may uniquely allow them to use distraction as a rehearsal device to reduce their forgetting. These first two studies explored the ability of both older and younger adults to use distraction as rehearsal under implicit or indirect instructions. This was done because implicit retrieval is generally age-invariant (e.g., La Voie & Light, 1994)\(^2\); therefore, implicit tests provide the most sensitive measure of older adults’ knowledge of distraction because they exert fewer demands on controlled retrieval. Indeed, past research indicates that older adults have enhanced implicit memory for distraction relative to younger adults (Kim et al., 2007; Rowe et al., 2006) and can tacitly transfer their knowledge of distraction to boost explicit recall performance (Campbell et al., 2010; Thomas & Hasher, 2012). In contrast, evidence of older adults’ ability to use distraction under direct, or explicit cueing instructions is mixed (e.g., Campbell et al., 2010; Connelly et al., 1991; Gopie, Craik, & Hasher, 2011; Thomas & Hasher, 2012).

A depiction of the general experimental procedure is shown in Figure 1. Participants studied and recalled a list of words for an initial recall test and a final surprise test following a 15-min delay. Some of the words were presented as distractors during an ostensibly unrelated 1-back task during the delay, providing an opportunity for these repeated study list words to be rehearsed as distraction. In order to ensure that the use of distraction as rehearsal occurred implicitly, instructions at final recall made no mention of the fact that some list words had

\(^2\) Unless there are similar items on the list, in which case older adults—who are differentially vulnerable to interference—show lower levels of implicit memory (Ikier & Hasher, 2006; Ikier et al., 2008; Lustig & Hasher, 2001).
repeated as distraction during the 1-back task, and awareness questionnaires were administered to ensure that retrieval was not contaminated by explicit retrieval strategies.

Figure 1. General experimental paradigm. Participants first studied and recalled a list of 20 words, which included two primacy and two recency buffers and 16 critical words. In the middle (Studies 1a, 3a, 3b, 4) or at the end (Study 2) of the 15-min. retention interval, participants performed a 1-back task on target pictures and were instructed to ignore the superimposed distracting words. These distracting words included eight of the critical words from the original study list (repeated words, e.g., MIRROR, ROSE). Recall was tested in a surprise, final test, and forgetting was compared for the 8 words that had repeated as distraction in the 1-back task (e.g., MIRROR, ROSE) and the 8 unrepeated words (e.g., CLOUD, WHEEL).

Study 1a

Study 1a was designed as an initial exploration of whether distraction could serve as a rehearsal opportunity for older but not younger adults. Two predictions follow from previous findings showing age differences in both initial susceptibility to and subsequent tacit use of distraction (Campbell et al., 2010; Kim et al., 2007; Rowe et al., 2006; Thomas & Hasher, 2012): (1) older adults would show reduced forgetting for words that re-occurred during the 1-back task compared to unrepeated words that only occurred in the original study list, and (2) younger
adults would show no difference in forgetting of items that repeated as distraction versus unrepeated items.

Method

Participants

Thirty-eight younger adults (M age = 19.6 years, SD = 2.3; range 18-27) and 40 older adults (M age = 68.2 years, SD = 4.5; range 62-77) participated in this study. All participants learned English prior to age five, reported being in good health, had normal or corrected-to-normal vision and hearing, and were free of psychiatric or neurological illness. Younger adults (14 male, 24 female) were students at the University of Toronto and received partial course credit or monetary compensation. Older adults (13 male, 27 female) were recruited from the community and received monetary compensation. Data from three younger and three older adults were replaced: One younger and one older adult had very poor performance on the 1-back task (more than 2.5 SDs below their respective group means), one older adult reported feeling ill, and two younger and one older adult reported both being aware of and using (or avoiding using) the repeated words.³

In terms of demographic variables, older adults (M = 17.9, SD = 6.2) had more years of education than younger adults (M = 13.3, SD = 1.7), t(45) = 4.53, p < .001. Older adults (M = 36.4, SD = 3.2) also scored significantly higher on the Shipley (1946) vocabulary test than younger adults (M = 30.9, SD = 4.2), t(69) = 6.44, p < .001, as would be expected from vocabulary growth over the adult years (e.g., Park et al., 2002). All older adults scored within

³ Removal of these aware participants did not affect the outcome or statistical significance of any analyses.
normal limits (range 28-30, \( M = 29.3, \) \( SD = 0.67 \)) on the Mini-Mental State Examination (MMSE), a standardized cognitive screening test (Folstein, Folstein, & McHugh, 1975).

**Materials**

The memory list contained 20 concrete nouns chosen from the MRC psycholinguistic database (Coltheart, 1981). The list included two buffers at the beginning and end of the list to reduce primacy and recency effects. The other 16 words included eight that were repeated as distraction on the 1-back task and eight that were not repeated. The two sets of eight words were counterbalanced so that each word appeared equally often as a repeated and unrepeated word across participants within an age group. Eight additional words appeared as fillers in the 1-back task, along with 24 nonwords. All word sets were matched for imageability (\( M = 592, \) \( SD = 32 \)), concreteness (\( M = 581, \) \( SD = 32 \)), frequency in written language (Kučera & Francis, 1967; \( M = 50 \) per million, \( SD = 17 \)) and word length (range = 4-7 letters, \( M = 5.3, \) \( SD = 1.0 \); Coltheart, 1981).

Target pictures for the 1-back task consisted of 42 line drawings selected from Snodgrass and Vanderwart (1980), which were coloured red to make them easily distinguishable from the words, which were presented in a black font.

**Procedure**

In this experiment, younger adult participants were tested throughout the day (10:00 a.m. to 5:00 p.m.; \( M = 12:48 \) p.m.), while older adults were tested in the afternoon (12:00 p.m. to 5:00 p.m.; \( M = 1:42 \) p.m.)\(^4\).

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\(^4\) Although older adults were tested at an off-peak time of day for the majority of older adults (Biss & Hasher, 2012; May & Hasher, 1998), time of testing was not associated with any critical measures in either age group. Thus, in all subsequent experiments, both younger and older adult participants were tested in the afternoon (1:00 p.m. to 5:00 p.m.), as is done in the majority of cognitive aging experiments (May, Hasher, & Stoltzfus, 1993).
A diagram of the general procedure can be seen in Figure 1. At study, words were presented for 3000 ms each with an interstimulus interval (ISI) of 500 ms. Participants then subtracted by threes from a specified number for 30 s and recalled aloud as many words as possible for 45 s. They were uninformed about a later test.

The 15 min retention interval began with a 5 min nonverbal task. This task was a modified version of the flanker task (Eriksen & Eriksen, 1974), in which participants made speeded responses to a central arrow that was surrounded by congruent (e.g., > > > > > >), neutral (e.g., x x x > x x x) or incongruent (< < < < < <) flanking distractors.

The 1-back task followed. In this task, participants were instructed to press a key whenever two consecutive pictures were identical and to ignore the superimposed words or nonwords (Campbell et al., 2010; Rowe et al., 2006). The picture and superimposed distracting word or nonword were presented for 1000 ms each, with an ISI of 500 ms. Each picture, word, and nonword occurred twice during the 1-back task. Repeated words always occurred with the same picture, while all other distracting items appeared with a different picture on each occurrence to ensure participants could not respond to 1-back trials based on the distracting words rather than on pictures. There were 15 pictures that repeated, requiring a 1-back response, and no memory list words appeared on these 1-back response trials. The 84 trials occurred as follows: 4 pictures presented alone, 8 pictures with superimposed nonwords, 64 pictures superimposed with either nonwords (32 trials), filler words (16 trials) or the critical repeated words (16 trials), then 8 pictures with superimposed nonwords.

Following the 1-back task, participants completed a second 5-min nonverbal filler task, which involved speeded detection of a target figure embedded in complex geometrical patterns (Ekstrom, French, Harman, & Derman, 1976).
At test, participants were reminded of the initial studied list and were asked to recall as many words as possible from that memory list for 45 s. A graded awareness questionnaire was then administered: Participants were first asked whether they noticed a connection between any of the tasks. If they reported repetition of recall-list words in the 1-back task, they were asked whether they consciously tried to use or avoid these items during final recall. Following the experimental tasks, all participants completed the vocabulary test (Shipley, 1940) and a brief background and health questionnaire. Older adults were administered the MMSE (Folstein et al., 1975), to screen for overall cognitive function.

Results and Discussion

Age differences in 1-back task performance were examined using accuracy and RT measures for the 15 pictures that repeated during the task. As accuracy scores were not normally distributed, nonparametric Mann-Whitney tests were used here and in all subsequent studies to examine group differences in the distribution of 1-back accuracy scores. Older adults were less accurate (Mdn = 93%, M = 92%, SD = 10%) in detecting picture repetitions than younger adults (Mdn = 100%, M = 96%, SD = 7%), U = 550, z = 2.34, p = .02, r = .26. Older adults were also slower (M = 582 ms, SD = 110 ms) to respond to repeated 1-back trials than younger adults (M = 516 ms, SD = 83 ms), t(76) = 2.95, p = .004, d = 0.68. Since age differences in accuracy are rarely found on typical 1-back tasks using visual stimuli without superimposed distractors (e.g., Dobbs & Rule, 1989; Mattay et al., 2006), this finding suggests that older adults were more distracted by the irrelevant words than were younger adults.

The percentage of items correctly recalled (see Table 1 for means) was analyzed in an age (younger, older) x test time (initial, final) x word type (repeated as distraction, unrepeated) mixed ANOVA with the latter two variables tested within-subjects. Overall, younger adults recalled
more words than older adults did, $F(1,76) = 6.62, p = .01, \eta^2_p = .08$, and recall decreased from the initial to the final test, $F(1,76) = 38.64, p < .001, \eta^2_p = .34$. However, both main effects were qualified by a reliable 3-way interaction among age, test time, and word type, $F(1,76) = 4.08, p = .05, \eta^2_p = .05$.

Table 1.
Percentage of words recalled at initial and final recall and forgetting scores in Study 1a and 1b.

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial Recall</th>
<th>Final Recall</th>
<th>Forgetting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unrepeated</td>
<td>Repeated</td>
<td>Unrepeated</td>
</tr>
<tr>
<td>Study 1a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Younger</td>
<td>41 (21)</td>
<td>40 (17)</td>
<td>35 (22)</td>
</tr>
<tr>
<td>Older</td>
<td>32 (18)</td>
<td>33 (17)</td>
<td>23 (16)</td>
</tr>
<tr>
<td>Study 1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Older</td>
<td>32 (9)</td>
<td>—</td>
<td>26 (11)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.

This 3-way interaction was explored using separate test time x word type ANOVAs within each age group. Younger adults showed overall forgetting, $F(1,37) = 18.28, p < .001, \eta^2_p = .33$, and this forgetting did not differ for repeated versus unrepeated words, $F < 1$.

Older adults also forgot items across the delay, $F(1,39) = 20.51, p < .001, \eta^2_p = .35$.

However, this main effect was qualified by an interaction between test time and word type: Older adults showed reduced forgetting of words that were repeated as distraction compared to unrepeated words, $F(1,39) = 8.39, p = .006, \eta^2_p = .18$. Thus, in accordance with predictions, older adults forgot fewer words that had repeated as distraction during the retention interval.

With the boost provided by repetition of studied items as distraction, older adults’ final recall of repeated items did not differ from that of young adults, $t(76) = 1.02, p = .31$, while
typical age differences were apparent for final recall of the unrepeated items, \( t(76) = 2.96, p = .004, d = 0.67 \). For ease of comparison across conditions, forgetting scores (percentage of items recalled at initial minus final recall) are presented in Figure 2. As is evident there and in Table 1, only older adults benefited from distraction that could serve as a rehearsal device. Presentations of useful distraction minimized older adults’ forgetting and dramatically eliminated age differences in recall for these items, with unrepeated words showing typical age differences.

![Figure 2](image)

*Figure 2.* Mean forgetting score (the percentage of words recalled in the initial test after study minus the percentage of words recalled after the delay) as a function of age group (younger vs. older adults) and word type (repeated as distraction vs. unrepeated) in Studies 1a and 1b. Error bars represent 95% confidence intervals.

Older adults’ increased distractibility during the 1-back task clearly enhanced their final recall of repeated words. Was this boost specific to repeated words, or was it the product of recalling words from the 1-back task itself—some of which were the repeated words from the initial list but others of which would be classified as intrusions? Older adults often produce a
larger number of intrusions during recall than younger adults, particularly intrusions from prior lists (e.g., Kahana, Dolan, Sauder, & Wingfield, 2005). Therefore, it is possible that older adults may show more extralist intrusions, including filler distracting words that were presented during the 1-back task. The overall rate of intrusions was compared between younger and older adults using nonparametric Mann-Whitney U-tests, since intrusion rates were not normally distributed. The number of total intrusions generated at final recall did not differ between younger \((Mdn = 1, M = 0.95 \text{ words, } SD = 1.14)\) and older adults \((Mdn = 0, M = 0.60 \text{ words, } SD = 0.96)\), \(U = 649, z = 1.23, p = .22\). Intrusions from among the filler distractors presented during the 1-back task were rare: Only one younger adult generated a single 1-back filler word as an intrusion \((M = 0.03 \text{ words, } SD = 0.16)\) and none were produced by older adults. Thus, there was no indication that older adults indiscriminately recalled extralist intrusions at final recall.

The results of this initial experiment indicate that repeating studied items as distraction reduced older adults’ forgetting of these items. In contrast, younger adults showed equivalent forgetting of repeated and unrepeated words. Notably, age differences in the ability to benefit from distraction that could cue rehearsal resulted in age-equivalent free recall of repeated words at the delayed test. This benefit for older adults occurred without producing a corresponding increase in the number of extralist intrusions they recalled.

Study 1b

The results of Study 1a suggest that using distraction as a rehearsal device may be a promising method to reduce older adults’ forgetting. However, a remaining question is whether the benefits of distraction for older adults occurred with or without cost to the unrepeated items. This question arises because of evidence that strengthening a subset of learned items through repetition can sometimes disrupt retrieval of others (e.g., Ratcliff, Clark, & Shiffrin, 1990;
Tulving & Hastie, 1972; but see Anderson, Bjork, & Bjork, 2000). That is, repeating items as
distraction may have resulted in a retrieval bias towards these items at the expense of memory
for unrepeated items, a possibility that would limit the potential utility of distraction-cued
rehearsal as a method to improve older adults’ memory.

To address this issue, 24 additional older adults were tested in a control condition in
which no words from the original study list occurred on the 1-back task. The performance of
these participants was compared to that of older adults in Study 1a. If reexposure to some items
as distraction disrupts retrieval of the other items, then more unrepeated words should be
forgotten in Study 1a compared to in Study 1b. In contrast, if distraction as a rehearsal device in
1a truly benefited memory without cost to other items, forgetting in Study 1b should be similar to
forgetting seen for unrepeated words in Study 1a.

Method

Participants

A new sample of 24 older adult ($M$ age = 67.1 years, $SD = 4.4$, range 61-77) participants
(5 male, 19 female) was recruited using the same criteria as in Study 1a. There were no
differences between this sample and older adults in Study 1a on measures of education ($M =
16.7, SD = 4.4$) or vocabulary ($M = 36.1, SD = 3.3$), $t s < 1.18, ps > .24$. As before, all participants
were cognitively healthy, as indicated by performance on the MMSE ($M = 29.6, SD = 0.6$, range
28-30), and MMSE scores did not differ from Study 1a participants, $t < 1$.

Materials and Procedure

The sole change from Study 1a was that eight new distracting words were selected to
appear in place of the repeated words used in the 1-back task in Study 1a. These words matched
the previous word lists on imageability ($M = 600$, $SD = 25$), concreteness ($M = 582$, $SD = 23$), frequency ($M = 54$, $SD = 24$) and length ($M = 5.3$, $SD = 0.7$; Coltheart, 1981).

Results and Discussion

Older adults in Study 1b performed similarly to those in 1a on the 1-back task in terms of both accuracy ($Mdn = 93\%$, $M = 92\%$, $SD = 10\%$), $U = 458$, $z = 0.04$, $p = .97$, and latency ($M = 589$ ms, $SD = 84$), $t < 1$.

Recall performance of these participants (see Table 1), for whom repeated versus unrepeated word type was a dummy variable, was then compared to that of older participants in the previous study using a study (1a, 1b) x test time x word type mixed ANOVA, with repeated measures on the second two factors. There was a main effect of test time, indicating overall forgetting, $F(1,62) = 37.57$, $p < .001$, $\eta_p^2 = .38$, and the test time x word type interaction was significant, $F(1,62) = 5.00$, $p = .03$, $\eta_p^2 = .08$. These effects were qualified by a reliable 3-way interaction among study, test time, and word type, $F(1,62) = 5.00$, $p = .03$, $\eta_p^2 = .08$. No other effects were significant, $Fs < 1.58$, $ps > 21$.

Given the significant 3-way interaction, forgetting in Study 1b was compared to older adults’ forgetting in the repeated and unrepeated conditions in Study 1a using separate study x test time mixed ANOVAs. Forgetting was reduced for repeated words in Study 1a compared to 1b, when no items from the memory list repeated as distraction, $F(1,62) = 4.65$, $p = .03$, $\eta_p^2 = .07$ (see Figure 2 for forgetting scores). In contrast, forgetting of unrepeated items in Study 1a did not differ from forgetting in Study 1b, $F < 1$. Thus, there is no evidence that distraction-based rehearsal of a subset of studied words in Study 1a disrupted retrieval of unrepeated words.

Since twice as many novel distracting words appeared in the 1-back task in Study 1b, it is possible that this increase in verbal material presented during the retention interval might have
elevated extralist intrusions at final recall relative to Study 1a. However, the overall number of intrusions generated in Study 1b ($Md = 1, M = 0.79, SD = 0.78$) did not differ from the number produced by older participants in Study 1a ($Md = 0, M = 0.60$ words, $SD = 0.96$), $U = 388, z = 1.42, p = .15$. Once again, the number of intrusions that appeared as distracting words on the 1-back task was at floor: Only two older adults in Study 1b each produced a single distracting word intrusion ($Md = 0, M = 0.08, SD = 0.28$).

This finding strengthens the conclusion from Study 1a that exposure to distraction that can serve as a rehearsal opportunity boosts the overall memory performance of older adults. Except for evidence of older adults’ spared recall of gist (e.g., Radvansky, Curiel, Zwaan, & Copeland, 2001) and personally meaningful information (e.g., grocery prices, Castel, 2005; safety-related information, May, Rahhal, Berry, & Leighton, 2005), findings comparable to the reduction of older adults’ forgetting and elimination of age differences in recall are rare. Given the potential theoretical and applied importance of a novel method to reduce age-related forgetting, subsequent experiments were performed to conceptually replicate this finding.

**Study 2**

Study 1a demonstrated that older, but not younger adults showed a recall advantage for studied words that repeated as distraction midway through a 15 min delay interval. The purpose of Study 2 was to provide a conceptual replication of older adults’ reduced forgetting for words that repeated as distraction. In addition, Study 2 explored whether the timing of the rehearsal opportunity influences whether younger and older adults demonstrate this mnemonic benefit. To this end, the procedure used in Study 1a was adapted so that studied items were repeated as distraction at the end of the delay interval, immediately before the final recall test.
Shifting the task timing may increase the benefit of distraction as rehearsal due to a closer match in temporal context between repetition of words as distraction and final recall (Howard & Kahana, 2002; Polyn, Norman, & Kahana, 2009). Contextual information naturally shifts across time, as external environmental information (e.g., the temperature of the laboratory, ambient auditory noise) and internal information (e.g., transitory thoughts or cognitive strategies, mood or body states) vary with each passing moment (Klein, Shiffrin, & Criss, 2007). According to contextual accounts of spaced repetitions, when an item is repeated, it is encoded with slightly different information on each presentation, consistent with these broad contextual fluctuations (Estes, 1955; Glenberg, 1979; Melton, 1970). This contextual shift is thought to influence the effectiveness of repeated study trials: When there is a short lag between the final repetition and a recall test, the contextual cues present at retrieval will more closely match the repetition context, thus increasing the magnitude of repetition effects and biasing retrieval towards more recently encoded information (Balota et al., 1989; Glenberg, 1976). Therefore, changing the timing of the 1-back task may alter the effects of distraction as a rehearsal device.

Based on evidence that a shortened delay between repetition and recall can cue retrieval of recently repeated information, it was anticipated that even younger adults might be cued to use helpful distraction that occurs immediately prior to recall. Older adults were expected to continue to show reduced forgetting of words that repeated as distraction, and perhaps benefit to an even greater degree than observed in Study 1a, given the greater contextual similarity between repetition and retrieval.
Method

Participants

Thirty-six younger adults (*M* age = 20.3 years, *SD* = 2.0, range 17-25; 9 male, 27 female) and 28 older adults (*M* age = 68.6 years, *SD* = 5.2, range 60-78; 11 male, 17 female) were recruited using the same criteria as in Studies 1a and 1b. Data from six younger and one older participant were replaced: One younger and one older adult had poor performance on the 1-back task (more than 2.5 SDs below the group means), and five younger adults reported both awareness and conscious use or avoidance of repeated words at final recall.

As in Study 1a, younger adults (*M* = 14.2, *SD* = 1.8) had fewer years of education compared to older adults (*M* = 16.7, *SD* = 3.4), *t*(38) = 3.49, *p* = .001. Younger adults (*M* = 29.7, *SD* = 3.7) also had lower vocabulary scores than older adults (*M* = 36.0, *SD* = 2.2), *t*(58) = 8.40, *p* < .001. Cognitive status on the MMSE (Folstein et al., 1975) was in the normal range for all older adults (range 27-30, *M* = 29.0, *SD* = 1.0).

Materials and Procedure

Materials and procedure were similar to those used in Study 1a. The sole change was the order of tasks in the 15 min interval between initial and final recall: In this study, the 1-back task occurred 10 min into the filled interval, immediately before the final recall test.

Results and Discussion

Younger adults were more accurate on the 1-back task (*Mdn* = 100%, *M* = 97%, *SD* = 8%) than older adults (*Mdn* = 100%, *M* = 94%, *SD* = 9%), *U* = 366, *z* = 2.36, *p* = .02, *r* = .30. Although in the predicted direction, the difference between 1-back RTs on repeated picture trials
for younger ($M = 532 \text{ ms, } SD = 67$) and for older ($M = 569 \text{ ms, } SD = 123$) adults did not reach significance, $t(39) = 1.43, p = .16$.

Recall performance was entered into an age x test time x word type mixed ANOVA (see Table 2 for means). As before, main effects of age, $F(1,62) = 9.73, p = .003$, $\eta^2_p = .14$, and test time, $F(1,62) = 19.33, p < .001$, $\eta^2_p = .24$, were reliable. These effects were qualified by a significant test time x word type interaction, $F(1,62) = 15.21, p < .001$, $\eta^2_p = .20$, indicating reduced forgetting of repeated compared to unrepeated words overall. In this study, the 3-way interaction did not reach a .05 criterion, $F(1,62) = 2.95, p = .09$, $\eta^2_p = .05$. However, given the results of Study 1a, the data were analyzed as before.

Table 2.
Percentage of words recalled at initial and final recall, and forgetting scores in Study 2.

<table>
<thead>
<tr>
<th>Group</th>
<th>Unrepeated</th>
<th>Repeated</th>
<th>Unrepeated</th>
<th>Repeated</th>
<th>Unrepeated</th>
<th>Repeated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger</td>
<td>42 (22)</td>
<td>40 (18)</td>
<td>35 (25)</td>
<td>36 (20)</td>
<td>7 (12)</td>
<td>4 (11)</td>
</tr>
<tr>
<td>Older</td>
<td>29 (18)</td>
<td>30 (16)</td>
<td>20 (14)</td>
<td>29 (16)</td>
<td>9 (10)</td>
<td>1 (10)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.

For younger adults, there was a nonsignificant trend towards decreased forgetting of words that had repeated as distraction compared to unrepeated words, $F(1,35) = 3.18, p = .08$, $\eta^2_p = .08$. Nevertheless, as can be seen in Figure 3, younger adults reliably forgot both repeated and unrepeated words between the initial and final recall tests.
Figure 3. Mean forgetting score (the percentage of words recalled in the initial test after study minus the percentage of words recalled after the delay) as a function of age group (younger vs. older adults) and word type (repeated as distraction vs. unrepeated) in Study 2. Error bars represent 95% confidence intervals.

As before, older adults showed less forgetting of items that had been repeated as distraction compared to those that had not been, \( F(1,27) = 11.82, p = .002, \eta_p^2 = .31 \). It is evident from Figure 3 that while older adults showed typical forgetting of unrepeated words, they showed no forgetting of repeated words. As a result, there were no age differences in final recall of repeated words, \( t(62) = 1.49, p = .14 \), while age differences were evident for unrepeated words, \( t(62) = 2.97, p = .004, d = 0.77 \).

As in Study 1a, the number of intrusions produced at final recall was compared between younger and older adults. Once again, the number of overall intrusions did not differ between younger (\( Mdn = 0, M = 0.64, SD = 0.96 \)) and older (\( Mdn = 1, M = 0.79, SD = 0.96 \)) adults, \( U = 446, z = 0.87, p = .40 \). Only two younger adults (\( Mdn = 0, M = 0.06, SD = 0.23 \)) each generated a distracting filler word from the 1-back task as an intrusion, while none were produced by older
adults. The number of intrusions produced by younger and older adults in this experiment resembles those produced in Study 1a; thus, it does not appear that changing the timing of the 1-back task affected the tendency to generate extralist intrusions.

These results indicate that repeating words from a memory list as distraction boosts older adults’ memory for these items whether the rehearsal opportunity occurs in the middle of the retention interval or immediately prior to retrieval. In Study 2, repeating words as distraction completely eliminated older adults’ forgetting of these items, and again eradicated age differences in final recall of these words. While it is possible that the contextual similarity between re-exposure to items as distraction and final recall may have cued some younger adults to take advantage of this distraction (Balota et al., 1989; Glenberg, 1979; Howard & Kahana, 2002), the trend towards reduced forgetting of repeated compared to unrepeated words among younger adults was not significant. Thus, this study adds to the conclusion of Study 1a that older adults can use distraction as a rehearsal device under implicit conditions, such that their forgetting is reduced and their recall is improved to the level of younger adults.

Studies 1 and 2: General Discussion

The dramatic finding across these two studies is that using distraction as a rehearsal device minimizes (Study 1a) and even eliminates (Study 2) age-related forgetting. Older adults showed little or no forgetting for words repeated as distraction, but marked forgetting for unrepeated words. By contrast, younger adults showed reliable forgetting for both types of words. Moreover, there was no suggestion that older adults demonstrated this benefit because they were indiscriminately recalling words from the 1-back task: Their intrusion rates for filler distracting words were at floor—as was the case for younger adults. Perhaps the most remarkable
finding here is that older adults’ final recall of words that were repeated as distraction was actually the equivalent of younger adults’—a finding that generally only occurs in the aging and memory literature when memory for gist-level (Radvansky et al., 2001) or important and emotionally salient (Castel, 2005; May et al., 2005) information is tested. This rare finding is important given the near-ubiquity of age-related deficits on tests requiring controlled memory retrieval (e.g., Balota et al., 2000; Grady & Craik, 2000; Zacks & Hasher, 2006), particularly under free recall conditions, which lack environmental support (Craik, 1986). Together, these results bolster the conclusion that repeating items as distractors makes them differentially accessible for older adults.

Older adults evidently processed and remembered irrelevant information during the 1-back task that younger adults successfully ignored, consistent with age-related decrements in inhibitory control (Hasher et al., 1999; Hasher & Zacks, 1988). Adding to previous evidence that repetitions occurring as target information boost older adults’ memory (Balota et al., 1989; Cohen et al., 1987; Logan & Balota, 2008; Morrow et al., 1999), these results suggest that distraction can serve as an additional source of rehearsals for older adults. Study-list items were repeated as distraction independently of the goal-relevant task and without intentional instructions to restudy or rehearse the original study list. This is consistent with the idea that spaced repetitions can boost free recall under incidental, in addition to intentional, study instructions (Greene, 1989).

Recent evidence indicates that older adults may even spontaneously rehearse irrelevant competitor items that should be rejected in order to perform a current task, as seen on a subsequent naming time task on which they were quicker to name these competitor items (Healey, Hasher, & Campbell, 2013). Taken together with the results described here, these findings suggest that older adults may unintentionally rehearse or retrieve past memoranda when
cued by irrelevant information. The inhibitory control view predicts that older adults are generally more prone to this sort of spontaneous thought, as inefficient inhibition means that irrelevant contextual details can cue activation of a broad range of thoughts and memories (Hasher & Zacks, 1988).

In addition to distraction-based rehearsal occurring without older adults’ intention to practice this information, the mnemonic boost at final recall also appears to have occurred implicitly. Since final recall instructions made no mention of these repetitions and all included participants were unaware of the connection between tasks, repeated study opportunities in the form of distraction appear to have boosted older adults’ final recall performance without awareness that they were retrieving these repetitions. This effect is consistent with evidence elsewhere that implicit or automatic retrieval of past information is largely preserved in aging (e.g., La Voie & Light, 1994), and can work in concert with recollection to contribute to explicit memory performance (Campbell et al., 2010; Jacoby, 1991; Thomas & Hasher, 2012). This implicit process may be particularly beneficial because, unlike effortful memory strategies, it is unlikely to be disrupted by stereotype threat effects associated with negative beliefs about aging and memory (e.g., Mazerolle, Régner, Morisset, Rigalleau, & Huguet, 2012). Thus, the ability to benefit from distraction as a covert reminder opportunity appears to rely on these preserved implicit and automatic processes that support remembering among older adults.
Chapter 3: Distraction as Rehearsal: Effects of Direct Cueing

In the previous studies, I interpreted older adults’ consistent advantage for repeated words as the result of a strengthening of memory traces via reexposure to this material as distraction during the 1-back task. More specifically, older adults’ decreased ability to filter out irrelevant information (Hasher et al., 2007, 1999; Hasher & Zacks, 1988) may have allowed for items repeated as distraction to receive additional encoding and rehearsal during the retention interval, thereby increasing the likelihood that these items would subsequently be remembered. In contrast, younger adults’ efficient inhibitory control over concurrent distraction may have allowed them to limit processing of irrelevant words in the 1-back task, so that repeated words received no additional strengthening.

An alternative interpretation is that the benefit for repeated items instead reflects a retrieval effect that is relied on more by older compared to younger adults. That is, older adults may be more likely than younger adults to rely on an unconstrained implicit- or familiarity-based retrieval strategy and therefore imprecisely recall information, such as distraction that was encountered during the retention interval. According to this explanation, it is possible that younger adults also coded items occurring as distraction, but they may have avoided retrieving this information because they adopted a controlled retrieval strategy to selectively recall representations encoded during initial study of the word list. This alternative interpretation of the results might be predicted by evidence that older adults are less able than younger adults to constrain retrieval to specific list items (B. A. Anderson et al., 2011; Jacoby, Shimizu, Velanova, & Rhodes, 2005), monitor source information (Johnson, Hashtroudi, & Lindsay, 1993; K. J. Mitchell & Johnson, 2009), and dampen activation of retrieved irrelevant information (Hasher et al., 1999; Healey et al., 2013; Healey, Ngo, & Hasher, 2014). It should be noted that the intrusion
rates in the prior studies were very low and argue against the perspective that older adults indiscriminately used distraction when recalling the original list. However, it remains possible that age differences in the type of retrieval engaged at final recall may have influenced the extent of age differences in the ability to benefit from distraction.

The goal of Studies 3a and 3b was to help distinguish between these strengthening and retrieval interpretations of age differences in the ability to take advantage of distraction as a rehearsal device. To this end, two modifications were made to the 3-stage procedure used in the previous experiments (see Figure 1), one to assess the retrieval interpretation and one to assess the rehearsal interpretation.

To assess retrieval, some participants were given direct, or explicit, cueing instructions at final recall that some of the original memory list words had repeated as distraction during the delay. The reasoning for this first modification was that direct cueing instructions would encourage participants to broaden retrieval constraints to include any distracting information that had been encoded. Memory performance was compared between participants who received these direct retrieval instructions and participants who, as in the previous studies, were not cued about the potential relevance of the distraction (i.e., an indirect instructions condition). In addition, source memory for the distracting items was probed by asking a subset of participants in the direct cueing condition to judge whether they remembered each recalled word as having occurred as distraction in the 1-back task.

To assess rehearsal, the 1-back task was adapted to allow us to more directly assess online processing of distraction during that task. The previous studies measured accuracy and RT only on repeating picture 1-back trials, and demonstrated that older adults were less accurate and slower than younger adults. Here participants made a “yes” or “no” response on every trial to indicate whether consecutive pictures were identical or not. Performance was measured on each
trial, which enabled an analysis of whether individuals are specifically distracted on trials on which repeated studied words occurred as superimposed distraction, relative to performance when novel words or nonwords appear as distraction. Slowed 1-back judgments for repeated words would support the idea that presentations of distraction are used as an opportunity to tacitly rehearse and strengthen words from the original study list.

Thus, I sought to uncover the source of age differences in access to words that repeated as distraction. More specifically, we examined the possibility that older adults are operating largely on the basis of an unconstrained, implicit retrieval mode whereas younger adults encode distraction but use controlled processes to exclude this irrelevant information from their final recall. These studies also tested for evidence that participants find repeated words particularly distracting during the 1-back task by examining whether repeated word distractors slow target task RTs relative to other types of distractors. In order to better understand the role of these potential mechanisms within each age group as well as to simplify the experimental design, Study 3a explored these questions in younger adults only, while Study 3b tested the same procedure in older adults.

**Study 3a: Younger Adults**

It is possible that younger adults did not benefit from distraction in the previous experiments because they adopted a controlled retrieval strategy at final recall to exclude any encoded distracting information from being retrieved (Jacoby et al., 2005; Johnson et al., 1993). This possibility was tested in Study 3a by providing younger adults with direct instructions at final recall that some study list items had occurred as distraction during the delay interval. If younger adults had encoded the distraction—but were using constrained retrieval or source
monitoring—direct instructions should enable them to benefit from the distraction by broadening their retrieval to include this information.

This outcome might be predicted by several studies demonstrating that younger adults can sometimes access representations of prior distraction when explicitly cued to do so. For example, younger adults were able to subsequently recognize distracting words that had been interspersed with the text of a target story (Dywan & Murphy, 1996; Kemper & McDowd, 2006; Thomas, 2009). In addition, when instructed that a new memory list contained some words that had earlier occurred as distracting text in a story, younger adults’ recall of these previously distracting words was enhanced relative to the recall of novel words (Thomas & Hasher, 2012). Another study demonstrated that younger adults were able to retrieve prior distraction when their explicit retrieval was cued by word fragments (Gopie, Craik, & Hasher, 2011; but see Amer, 2012 for a nonreplication of this result). It should be noted that these studies included many presentations of each distractor (i.e., 10-20 occurrences, Dywan & Murphy, 1996; Kemper & McDowd, 2006; Thomas & Hasher, 2012) or used a long stimulus presentation and interstimulus interval (Gopie et al., 2011); this extensive exposure to distracting items may have encouraged younger adults to attend to these items. Thus, while these particular findings suggest that younger adults do encode distraction so that it is later accessible via explicit retrieval, it is possible that distraction was presented in a manner that encouraged encoding of this information, rather than ensuring that it was considered irrelevant.

By contrast, studies using a 1-back task similar to the one used here have avoided this problem by presenting target and distracting stimuli rapidly and on few occasions (i.e., 1-3 presentations; Butler & Klein, 2009; Campbell et al., 2010; Hoffman, Bein, & Maril, 2011; Rees et al., 1999). These studies instead suggest that younger adults have minimal explicit memory for prior distraction. For example, Campbell and colleagues (2010) asked participants to match
distracting words with the target pictures they were paired with during a previous 1-back task. They found that younger adults showed no explicit knowledge of target-distractor pairings, with matching performance at chance level. Other work indicates that younger adults’ recognition of distracting words from a similar 1-back task did not differ from chance on standard yes/no recognition tests (Butler & Klein, 2009; Hoffman et al., 2011; Rees et al., 1999). However, when recognition misses were broken down into high and low confidence responses, distracting words from the 1-back task received more low confidence “no” responses compared to new items (Hoffman et al., 2011), suggesting that they were perceived as more familiar on this possibly more sensitive explicit memory measure. Thus, studies using methods to more carefully ensure that younger adults follow task directions to ignore distraction suggest that younger adults do limit encoding of distracting information, such that they are unable to retrieve this material on a subsequent explicit memory test unless very sensitive measures are used.

Can younger adults explicitly retrieve distraction in the procedures used in the present studies? The goal of Study 3a was to determine whether younger adults can access repetitions that occurred as distraction when directly cued about their relevance at final recall. The order of tasks from Study 1a was again used; that is, the 1-back task occurred midway through the retention interval. Given the inconsistent findings reviewed above regarding whether younger adults can access prior distraction on explicit memory tests, two potential outcomes were anticipated. If younger adults do successfully ignore distracting words in the 1-back task, then they should continue to show reliable forgetting of repeated words under direct cueing instructions. If younger adults instead encode and rehearse the distracting words but adopt a controlled retrieval strategy to avoid implicitly retrieving distraction, direct retrieval instructions may permit them to show a benefit from distraction. Additionally, if younger adults process the repeated words when they are reexposed as distraction, they should also show evidence of
differential slowing on 1-back task trials in which a repeated, as opposed to a novel control word is presented.

Method

Participants

Seventy-five younger participants (age range 17-29 years; 27 male, 48 female) were recruited using the same criteria as reported in the previous studies. Thirty younger adults were assigned to the indirect instruction condition, and 45 were assigned to the direct instruction condition. Data from three participants in the indirect cueing condition who reported both awareness and deliberate use or avoidance of the repeated words, as well as from one participant in the direct cueing condition with poor performance on the 1-back task (more than 2.5 SDs below the group mean) were replaced with data from new participants.

In terms of demographic measures, there was no difference between retrieval instruction groups on age (indirect: $M = 18.9$ years, $SD = 1.9$; direct: $M = 19.3$, $SD = 2.5$), years of education (indirect: $M = 13.0$, $SD = 1.4$; direct: $M = 13.3$, $SD = 1.7$), or vocabulary scores (indirect: $M = 30.9$, $SD = 4.5$; direct: $M = 30.7$, $SD = 3.4$), $ts < 1$.

Materials and Procedure

Picture and word stimuli were the same as those used previously, with the exception that now three sets of eight items (repeated, unrepeated and novel distractor words in the 1-back task, instead of two sets as in Studies 1a and 2) were counterbalanced across participants.

The timing of tasks was the same as in Study 1a, with the 1-back task occurring midway through the 15-min delay interval. For the 1-back task, participants were now asked to make a response on each trial, pressing a “yes” key if the current picture was the same as the one previously shown, and “no” if it was not. Participants were given 20 picture-only practice trials
to familiarize them with the response keys and speed of the task. All distractor words and letter strings occurred twice on the 1-back task, each time with a different picture, with the exceptions of repeated and novel distractor words, which occurred with the same picture on both presentations. Repeated and novel distractor words always occurred on “no” response trials, and there were 16 repeated-word, 16 novel-word, and 18 nonword distractor trials used to compare RTs on “no” response trials when different distracting items appeared.

The recall and filler tasks were identical to those used in the previous experiments, with the exception that participants in the direct cueing condition were informed during the final recall instructions that some items from the study list had repeated as distraction on the 1-back task. After being instructed to recall as many of the original study list words as possible, these participants were told, “Some of these words also appeared as the overlapping words in the pictures task, and perhaps will help you to recall.” All other instructions were the same for the indirect and direct conditions.

Following final recall, 15 participants in the direct instructions condition were asked to judge whether they remembered each recalled word as having occurred as a distractor. That is, the experimenter read out loud each word produced by the participant during the final recall test, and asked the participant to respond “yes” or “no” to indicate whether they thought that word had been presented as a distractor during the 1-back task. The percentage of words judged to have occurred as distraction was compared between repeated and unrepeated words, as well as for any distractor word intrusions produced at final recall.
Results and Discussion

1-back Task Performance

Younger adults’ accuracy on the 1-back task approached ceiling and did not differ between indirect ($Mdn = 98\%, M = 97\%, SD = 3\%$) and direct ($Mdn = 98\%, M = 97\%, SD = 3\%$) instruction conditions, $U = 660$, $z = 0.16$, $p = .87$.

To address the question of whether younger adults’ responses were slowed on 1-back task trials on which a repeated study list word was presented as distraction, RTs for “no” response trials were compared between trials with a repeated word, novel word, or nonword distractor. 1-back task RTs for correct trials were first trimmed by removing responses more than 2.5 SDs faster or slower than each participant’s cell mean (this resulted in removal of 1.9\% of trials). These trimmed mean RTs were then entered into a retrieval instructions (indirect, direct) x distractor type (nonword, repeated word, novel word) mixed ANOVA, with distractor type tested within subjects (see Table 3 for means). There was a significant main effect of distractor type, $F(2,146) = 13.79$, $p < .001$, $\eta^2_p = .16$. No other effects were significant, $Fs < 1$.

<table>
<thead>
<tr>
<th>Group</th>
<th>Nonword</th>
<th>Novel word</th>
<th>Repeated word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect</td>
<td>471 (96)</td>
<td>490 (108)</td>
<td>497 (116)</td>
</tr>
<tr>
<td>Direct</td>
<td>480 (84)</td>
<td>491 (80)</td>
<td>500 (92)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.

The significant main effect of distractor type on response times was further examined using post hoc tests with Bonferroni correction as implemented in SPSS 20. Response times were slowed for repeated ($M = 499$ ms, $SD = 102$ ms) and novel word ($M = 490$ ms, $SD = 92$ ms)
compared to nonword distractors ($M = 477$ ms, $SD = 89$ ms), $p < .001$ and $p = .003$ respectively. Younger participants were not, however, differentially slowed when repeated words from the memory list served as distractors compared to novel words, $p = .23$. These results indicate that younger adults were more susceptible to word compared to nonword distractors. Critically, however, they were not differentially distracted by repeated words from the study list compared to novel words. This suggests that younger adults did not process the broader significance or covertly retrieve the original studied representations of these words when they were reexposed as distraction, processes that may have provided an opportunity for these items to be strengthened or rehearsed.

Recall Performance

The percentage of words correctly recalled was analyzed using a retrieval instruction (indirect, direct) x test time x word type mixed ANOVA, with test time and word type tested within subjects (see Table 4 for means). Forgetting occurred between initial and final recall, $F(1,73) = 51.47, p < .001, \eta_p^2 = .41$. In addition, there was a significant 3-way interaction among retrieval instructions, test time, and word type, $F(1,73) = 6.21, p = .01, \eta_p^2 = .08$, indicating that the pattern of forgetting varied according to instructions at retrieval. No other main effects or interactions approached significance, $Fs < 1.65, ps > .20$; thus, there was no indication that overall recall or forgetting across the delay differed between retrieval instruction groups.
Table 4.
Percentage of words recalled at initial and final recall, and forgetting scores in Study 3a.

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial Recall</th>
<th>Final Recall</th>
<th>Forgetting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unrepeated</td>
<td>Repeated</td>
<td>Unrepeated</td>
</tr>
<tr>
<td>Study 3a: Younger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td>40 (20)</td>
<td>38 (22)</td>
<td>37 (20)</td>
</tr>
<tr>
<td>Direct</td>
<td>45 (15)</td>
<td>41 (20)</td>
<td>35 (18)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.

To simplify the analysis, the 3-way interaction was further explored using forgetting scores (initial – final recall) on repeated versus unrepeated items. In particular, the differential pattern of forgetting between instruction groups was examined to address the experimental question of whether younger adults can make use of direct instructions to reduce their forgetting of repeated items. Under indirect instructions, forgetting did not differ for repeated versus unrepeated words, $t(29) = 1.22, p = .23$. By contrast, forgetting in the direct instruction condition was significantly different between repeated and unrepeated words, $t(44) = 2.45, p = .02, d = 0.37$. As is apparent through examination of forgetting scores in Figure 4 below, this effect was caused by differences in the forgetting of unrepeated words, rather than a benefit for words that repeated as distraction. Two pairwise contrasts on forgetting scores show this directly: Younger adults showed similar forgetting for repeated words under both instruction conditions, $t < 1$. By contrast, forgetting of unrepeated words was significantly increased under direct compared to indirect instructions, $t(73) = 2.63, p = .01, d = 0.60$. Thus, younger adults’ forgetting of words that had repeated as distraction did not change when given explicit instructions about the relevance of the distraction, but rather, these cueing instructions appear to have biased their recall away from unrepeated words. Of course, rather than a bias away from unrepeated items, it
is possible that this result might be spurious. As is also evident in Figure 4, younger adults continued to show reliable forgetting of both repeated and unrepeated words, regardless of retrieval instructions.

![Figure 4](image)

*Figure 4.* Mean forgetting score (the percentage of words recalled in the initial test after study minus the percentage of words recalled after the delay) as a function of retrieval instructions (indirect vs. direct), and word type (repeated as distraction vs. unrepeated) for younger adults in Study 3a. Error bars represent 95% confidence intervals.

Did direct instructions about the usefulness of past distraction influence the number of intrusions produced at final recall? While the total number of intrusions appeared numerically higher among younger adults in the direct instructions condition ($Mdn = 1, M = 1.33, SD = 1.46$), this intrusion rate did not significantly differ from the indirect instruction condition ($Mdn = 1, M = 0.77, SD = 0.90$), $U = 549, z = 1.45, p = .15$. Thirteen participants in the direct condition ($Mdn = 0, M = 0.36 SD = 0.65$) and three participants in the indirect instructions condition ($Mdn = 0, M = 0.10, SD = 0.31$) produced at least one intrusion from among the filler distracting words in the 1-back task.
Given that direct instructions were designed to encourage participants to retrieve information encoded during the 1-back task, an open question is whether younger adults are able to access accurate source information about whether recalled words had occurred during that task. As a preliminary exploration of this question, 15 participants in the direct retrieval instructions condition were asked yes or no questions about whether they remembered each word they produced at final recall as having occurred as distraction during the 1-back task. Participants did not accurately discriminate whether individual words occurred as distraction in the 1-back task: They correctly identified 36% (SD = 36%) of recalled repeated words as having been presented as distraction; however, this did not differ from false alarms to unrepeated words (M = 24%, SD = 30%), t(14) = 1.08, p = .30. This exploratory analysis suggests that younger adults have little access to source information about whether recalled words had occurred as distraction, although a larger sample is required to more fully explore this question.

The results of Study 3a demonstrate that instructing younger adults about the usefulness of distraction did not result in a mnemonic benefit for repeated words: Younger adults still forgot repeated words across the delay, with forgetting of repeated words that was similar across instruction conditions. This lack of a memory benefit for repeated words among younger participants, even when explicitly cued that this information could aid their recall, suggests that younger adults did not encode distractors in the 1-back task, at least in a manner sufficient to support strengthening of repeated items. Additional evidence that younger adults ignored or only minimally processed repeated words when they appeared as distraction comes from an analysis of 1-back task RTs: No differential slowing was observed on trials with repeated word distractors compared to trials with a novel distracting word. Furthermore, a follow-up analysis with a small group of participants suggested that younger adults did not have access to accurate source
information about which of the words they produced at final recall had occurred in the 1-back task. Together, these results suggest that younger adults’ failure to benefit from presentations of distraction is not due to the use of a controlled retrieval strategy to eliminate this information from final recall, but rather is a result of successful inhibition of distraction when it is presented.

Instead of benefiting younger adults’ memory for words that repeated as distraction, direct retrieval instructions shifted what was recalled in a negative direction by exacerbating forgetting of unrepeated items relative to younger adults who received indirect instructions. What type of mechanism might explain this retrieval bias away from unrepeated words among younger adults in the direct cueing condition? One possible mechanism operating here could be similar to the retrieval-induced forgetting phenomenon, which occurs when practicing a subset of categorized items from a study list results in greater forgetting of other items in that category (M. C. Anderson, Bjork, & Bjork, 1994). This effect would have to occur implicitly, since there was no evidence here that younger adults actively practiced or even recognized distraction when it occurred during the 1-back task. The retrieval-induced forgetting effect involves explicit retrieval of practiced items (e.g., M. C. Anderson et al., 1994; M. C. Anderson & Spellman, 1995), so it is unclear whether such an effect would occur if rehearsals are not intentional, as was the case here. In addition, the retrieval-induced forgetting effect is associated with improved recall for practiced items; thus, another problem with this explanation is that there was no evidence that younger adults’ recall of repeated words was enhanced. An alternative possibility is that cueing younger adults to use distraction may have disrupted their natural retrieval strategies, as sometimes occurs when some items from a memory list are used as retrieval cues (Basden & Basden, 1995). In any case, it is unclear why younger adults show exacerbated forgetting of unrepeated words under direct instructions conditions, and it remains possible that this is a
spurious finding. What is evident, however, is that younger adults appear to be unable to benefit from exposure to distraction that can serve as a rehearsal device.

**Study 3b: Older Adults**

Study 3b examined the effect of explicit cueing conditions on older adults’ ability to benefit from distraction as a rehearsal opportunity. Since older adults demonstrated reduced forgetting for items that had repeated as distraction when unaware of these repetitions in Studies 1a and 2, one might predict that they will continue to show the same benefit when informed that these repetitions occurred. Indeed, past research indicates that older adults transfer knowledge of past distraction in a comparable manner whether they are given indirect or direct cueing instructions (Thomas & Hasher, 2012). However, it is possible that the benefit from distractor-based rehearsals may be reduced if explicit cueing disrupts implicit retrieval mechanisms that normally facilitate transfer of past distraction. For example, in one study using word fragment completion to test implicit and explicit memory for previously distracting words, older adults showed markedly reduced memory performance under explicit instructions (Gopie et al., 2011). Since instructions that emphasize intentional memory demands are known to induce stereotype threat effects related to older adults’ negative beliefs about their memory abilities (Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Mazerolle et al., 2012; Rahhal, Hasher, & Colcombe, 2001), it is possible that explicit cueing may reduce older adults’ ability to show the benefit they otherwise would demonstrate from distraction as a repetition opportunity.

A second question explored in Study 3b was whether older adults would show greater distractibility on trials with a repeated word, as opposed to a novel word distractor. Greater distractibility on these trials would provide supportive evidence that presentations of distraction
provide an opportunity for rehearsal of these items. If older adults are differentially distracted by recently studied material then their responses should be slowed when target pictures are superimposed with repeated word distractors compared to their responses on trials with novel distractor words.

Method

Participants

Sixty older adult participants (age range 60-77 years; 11 male, 49 female) were recruited using the same criteria as reported in the previous studies. Thirty older adults were assigned to the indirect instruction condition, and 30 older adults participated in the direct instruction condition. Data from four participants with poor performance on the 1-back task (more than 2.5 SDs below their respective group means), and two participants who were outliers on the vocabulary test (more than 2.5 SDs below the older adult group mean) were replaced.

In terms of demographic information, age (indirect: $M = 67.4$ years, $SD = 4.8$; direct: $M = 69.2$, $SD = 4.9$), years of education (indirect: $M = 16.3$, $SD = 4.4$; direct: $M = 16.8$, $SD = 2.8$), and vocabulary scores (indirect: $M = 36.0$, $SD = 3.2$; direct: $M = 36.5$, $SD = 2.6$) did not differ between retrieval instruction groups, $t_s < 1.44$, $p_s > .15$. All older adults scored within normal limits on the MMSE cognitive screening test (range 27-30; Folstein et al., 1975), and MMSE scores did not differ between groups (indirect: $M = 29.1$, $SD = 1.0$; direct: $M = 29.3$, $SD = 0.7$), $t(58) = 1.04$, $p = .30$

Materials and Procedure

The materials and procedure used were identical to those used for younger adults in Study 3a.
Results and Discussion

1-back Task Performance

Older adults’ accuracy on the 1-back task did not differ between indirect (Mdn = 95%, M = 95%, SD = 4%) and direct (Mdn = 94%, M = 92%, SD = 7%) cueing conditions, U = 362.5, z = 1.30, p = .20. Older adults’ overall accuracy (Mdn = 95%, M = 93%, SD = 5%) was lower compared to that of younger adults tested in Study 3a (Mdn = 98%, M = 97%, SD = 3%), U = 1241, z = 4.50, p < .001, r = .39.

As was done for younger adults in Study 3a, RTs for correct trials were trimmed by removing responses more than 2.5 SDs faster or slower than each participant’s cell mean (this resulted in removal of 1.7% of older adults’ trials). Trimmed mean RTs were then entered into a retrieval instructions x distractor type mixed ANOVA, with repeated measures on the second factor (see Table 5 for means). Older adults were differentially slowed according to the distractor type, F(2,116) = 19.26, p < .001, ηp² = .25. No other effects were significant, F's < 1.

Table 5.
Mean 1-back RT (ms) per trial by type of superimposed distractor in Studies 3a and 3b.

<table>
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<tr>
<td>Study 3b: Older</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td>657 (132)</td>
<td>671 (146)</td>
<td>695 (145)</td>
</tr>
<tr>
<td>Direct</td>
<td>664 (154)</td>
<td>691 (145)</td>
<td>705 (165)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.
Post hoc comparisons using Bonferroni corrections as implemented in SPSS 20 were used to further explore the main effect of distractor type. Similar to their younger counterparts, older adults were slower on trials with a repeated ($M = 700$ ms, $SD = 154$ ms) or novel word ($M = 681$ ms, $SD = 145$ ms) distractor compared to trials with a nonword distractor ($M = 661$ ms, $SD = 142$ ms), $p < .001$ and $p = .007$ respectively. In addition, older adults were significantly slower on trials that included repeated compared to novel distractor words, $p = .01$. Thus, while both younger and older adults were more distracted by word compared to nonword distractors, only older adults were additionally slowed by previously-studied distracting words from the memory list relative to the novel word distractors.

Recall Performance

As was done for younger adults in Study 3a, older adults’ recall performance (see Table 6) was examined using a retrieval instruction x test time x word type mixed ANOVA, with the latter two factors tested within subjects. This analysis revealed a main effect of test time, $F(1,58) = 22.68, p < .001, \eta_p^2 = .28$, which was qualified by a significant test time x word type interaction, $F(1,58) = 8.75, p = .004, \eta_p^2 = .13$. That is, older adults’ forgetting was reduced for repeated compared to unrepeated words, and this advantage did not vary according to retrieval instruction condition, $F < 1$. No other effects were significant, $Fs < 1.09, ps > .30$. As is apparent in Figure 5, older adults’ forgetting was eliminated for repeated words. Furthermore, there was no suggestion of a stereotype threat effect here because a clear advantage for repeated words was apparent in both indirect and direct retrieval groups.
Table 6.
Percentage of words recalled at initial and final recall, and forgetting scores in Studies 3a and 3b.

<table>
<thead>
<tr>
<th></th>
<th>Initial Recall</th>
<th>Final Recall</th>
<th>Forgetting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unrepeated</td>
<td>Repeated</td>
<td>Unrepeated</td>
</tr>
<tr>
<td>Study 3a: Younger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td>40 (20)</td>
<td>38 (22)</td>
<td>37 (20)</td>
</tr>
<tr>
<td>Direct</td>
<td>45 (15)</td>
<td>41 (20)</td>
<td>35 (18)</td>
</tr>
<tr>
<td>Study 3b: Older</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td>35 (18)</td>
<td>33 (18)</td>
<td>27 (18)</td>
</tr>
<tr>
<td>Direct</td>
<td>32 (18)</td>
<td>29 (19)</td>
<td>24 (16)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.

Figure 5. Mean forgetting score (the percentage of words recalled in the initial test after study minus the percentage of words recalled after the delay) as a function of age group (younger vs. older adults), retrieval instructions (indirect vs. direct), and word type (repeated as distraction vs. unrepeated) in Studies 3a and 3b. Error bars represent 95% confidence intervals.
Direct instructions clearly had no effect on older adults’ forgetting, but could they have encouraged older adults to broaden their retrieval to include more intrusions? The total number of intrusions (see Table 7 for means) did not significantly differ between older adults in the direct ($Mdn = 1$) and indirect ($Mdn = 1$) instructions conditions, $U = 338, z = 1.75, p = .08$. Five participants in the direct instructions condition and one participant in the indirect instructions condition produced a 1-back distractor word as an intrusion.

Table 7.
Number of intrusion words recalled at final recall in Studies 3a and 3b.

<table>
<thead>
<tr>
<th>Group</th>
<th>Total intrusions</th>
<th>1-back distractor intrusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 3a: Younger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td>0.77 (0.90)</td>
<td>0.10 (0.31)</td>
</tr>
<tr>
<td>Direct</td>
<td>1.33 (1.46)</td>
<td>0.36 (0.65)</td>
</tr>
<tr>
<td>Study 3b: Older</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td>0.87 (1.20)</td>
<td>0.07 (0.37)</td>
</tr>
<tr>
<td>Direct</td>
<td>1.47 (1.53)</td>
<td>0.17 (0.38)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.

As in Study 3a, a subset of 15 participants in the direct instructions condition were asked yes or no questions about whether they remembered each word produced at final recall as having occurred as distraction during the 1-back task. Older adults correctly indicated that 39% ($SD = 41\%$) of recalled repeated words were seen as distraction and incorrectly classified 24% ($SD = 42\%$) of unrepeated words as having appeared as distraction in the 1-back task; these did not differ, $\tau(10) = 1.29, p = .22$. Thus, older adults’ judgments about whether recalled words had occurred as distraction did not reliably differ from chance performance. This exploratory analysis
suggests that like their younger counterparts, older adults had minimal access to accurate source information from the 1-back task.

How did older adults’ recall performance compare to that of younger adults in Study 3a? In order to determine whether repeating words as distraction boosted older adults’ recall performance to the level of younger adults, final recall of repeated and unrepeated words was compared between younger adults in Study 3a and older adults in Study 3b. As in the previous studies, repeating words as distraction eliminated age differences in final recall of these items: Across retrieval instruction conditions, younger (mean = 34%, SD = 19%) and older (mean = 29%, SD = 20%) adults did not differ on final recall of repeated words, t(133) = 1.38, p = .17, while standard age differences were apparent for final recall of unrepeated words (younger: mean = 36%, SD = 19%; older: mean = 26%, SD = 17%), t(133) = 3.17, p = .002, d = 0.55. Thus, repeating words as distraction improved older adults’ recall regardless of instructions at retrieval, resulting in reduced forgetting and no age differences in final recall of these items, as was seen in Study 1a and 2. As in the previous experiments, the number of intrusions produced at final recall was compared between age groups, to determine whether older adults showed more indiscriminate retrieval of distraction from the 1-back task or other extralist items. There was again no indication that older adults (Md = 1, M = 1.17, SD = 1.39) produced more intrusions at final recall compared to younger adults (Md = 1, M = 1.11, SD = 1.29), U = 2216, z = 0.16, p = .87.

This study replicated the finding that repeating items as distraction enhanced older adults’ memory performance when instructions were indirect or implicit, that is, when individuals were unaware that these repetitions occurred. Notably, older adults continued to show a mnemonic benefit for words that repeated as distraction under direct instruction conditions: Forgetting rates for repeated and unrepeated items paralleled those observed under indirect instructions and were
also similar to those observed in Studies 1a and 2. As instructions that emphasize explicit retrieval demands can sometimes disrupt older adults’ memory by inducing stereotype threat (Chasteen et al., 2005; Mazerolle et al., 2012; Rahhal et al., 2001), it is significant that the benefit for repeated items remains robust when explicit retrieval instructions are provided. Similar to younger participants, older adults do not appear to have retrieved specific source information about the distraction: Preliminary analyses with a limited sample of participants indicated that older adults did not reliably distinguish between study list words that had versus had not appeared in the 1-back task. This suggests that the rehearsal benefit for older adults remains the same whether instructions encourage explicit retrieval of the distraction or not.

This experiment also provided new evidence of greater interference on older adults’ 1-back task performance when repeated words, as opposed to novel words or nonwords, appeared as distraction. As older adults evidently paid attention to repeated words presented as distraction during the 1-back task, this additional processing of repeated words may have allowed for these items to be strengthened in memory. In sum, the results of Study 3b support the idea that repeating words from a memory list as distraction can serve as a type of memory-strengthening rehearsal for older adults.

Studies 3a and 3b: General Discussion

The purpose of Studies 3a and 3b was to explore strengthening versus retrieval interpretations of older adults’ unique ability to take advantage of distraction that can serve as a rehearsal opportunity. To review, a strengthening explanation would suggest that older adults’ greater distractibility (Hasher et al., 1999; Hasher & Zacks, 1988) allows for items that repeat as distraction to receive additional encoding and rehearsal. This interpretation suggests that, by
contrast, younger adults’ more efficient inhibitory control means that these distracting items are ignored and therefore receive no additional strengthening relative to words that only occurred in the original study list.

The retrieval interpretation might instead suggest that older adults show enhanced recall of repeated items because they indiscriminately retrieve distracting material from the 1-back task. According to this explanation, younger adults may also code items that are repeated as distraction, but they deploy a controlled retrieval strategy to eliminate distraction and other extralist representations from their recall. This retrieval interpretation might be predicted based on previous evidence that older adults have more difficulty than younger adults at constraining retrieval to specific list items (B. A. Anderson et al., 2011; Jacoby et al., 2005), monitoring the source of retrieved material (Johnson et al., 1993; K. J. Mitchell & Johnson, 2009), and dampening activation of retrieved irrelevant information (Hasher et al., 1999; Healey et al., 2013, 2014). This retrieval explanation was tested by directly cueing participants about the usefulness of distraction at final recall, with the reasoning that these instructions would encourage younger and older adults to retrieve any information presented as distraction that had been encoded.

Direct instructions did not affect older adults’ ability to benefit from distraction as a rehearsal device: Repeating words as distraction eliminated older adults’ forgetting of these items whether they were unaware or instructed about this repetition at final recall. Explicit instructions were unsuccessful at reducing younger adults’ forgetting of repeated words, and instead appear to have heightened their forgetting of unrepeated words relative to an uninstructed group of younger adults. Why might direct cueing have elevated unrepeated word forgetting? It is possible that recall disruption mechanisms as seen in retrieval-induced forgetting (M. C. Anderson et al., 1994) or a disruption in retrieval strategy from being cued to recall a subset of items (Basden & Basden, 1995) may underlie heightened forgetting of unrepeated words.
However, these effects are usually accompanied by enhanced recall of practiced or cued items, which was not observed here. It remains unclear why younger adults’ recall of unrepeated words was disrupted, and it is possible that this result is spurious. What is apparent is that cueing younger adults to broaden their retrieval to include distraction did not produce a benefit for repeated words that paralleled older adults’ performance. This suggests that age differences in the ability to benefit from distraction as a rehearsal opportunity are not merely the result of different retrieval strategies.

Also running contrary to the idea that older adults broadly and erroneously retrieve information from across the experimental context is the common result across experiments that their recall was improved for repeated words without a concomitant increase in intrusions relative to younger adults. That is, there is no indication that older adults indiscriminately used distraction (or other extralist items) when recalling the original studied list. At the same time, a preliminary test of source memory for distraction indicated that younger and older adults’ judgments of whether recalled study list words had also appeared on the 1-back task were at chance. It should be noted that this analysis was limited by a small sample size and the limited number of list words probed (i.e., only the study list words that participants had produced at final recall); a stronger test would be to present participants with all study list items in order for them to all be classified as repeated in the 1-back task or not. Future research is needed to more thoroughly test whether younger and older adults can accurately judge the source of information that was presented as distraction.

Study 3b provided additional evidence of older adults’ inefficient filtering of irrelevant information, thereby strengthening the position that age-related distractibility allows older adults to uniquely benefit from distraction as a rehearsal opportunity. Analysis of 1-back task RTs revealed greater interference to older adults’ target task performance when previously studied
words appeared as superimposed distraction as compared to when novel words appeared. By contrast, younger adults were not slower on trials with a repeated compared to a novel word distractor. Nonetheless, even younger adults appear to have processed distracting items to some extent, as both younger and older adults were more distracted by word compared to nonword distractors. Together, these results fit with past evidence that, while both younger and older adults find words more distracting than nonwords, only older adults tend to be differentially distracted by lexical material that is meaningful or significant in the current experimental context (Connelly et al., 1991). Thus, consistent with the view that older adults are less able to filter out concurrent distraction (Hasher et al., 1999), older adults were more distracted by repeated words, likely allowing memory for these items to be strengthened relative to study list items that did not occur as distraction.

Thus, along with the results of the previous experiments, Studies 3a and 3b support the conclusion that presentations of distraction increase the accessibility of repeated words for older, but not younger adults. Direct cueing instructions did not allow younger adults to reduce their forgetting of repeated words. There was no evidence for an age difference in the number of intrusions. Finally, only older adults were more distracted by old, repeated words compared to novel distractor words in the 1-back task. Together, these results suggest that older adults’ unique advantage for repeated items is not merely because they are more likely than younger adults to indiscriminately retrieve information from the 1-back task. Instead, results provide stronger evidence for the interpretation that this benefit is due to rehearsal or strengthening of the memory trace of repeated items. That is, older adults’ difficulty ignoring distraction counterintuitively produces a mnemonic boost when presentations of distraction can serve as memory-strengthening rehearsals.
Chapter 4: Distraction as Rehearsal: Effects of Mood

While the previous studies focused on the effects of aging, additional factors, such as emotional states, also influence what information people attend to and remember. In particular, the valence or pleasantness of one’s mood can influence the breadth of attention. Negative affect, especially when coupled with high arousal, is thought to narrow attention to central information at the expense of memory for peripheral details (e.g., Derryberry & Tucker, 1994; Easterbrook, 1959). In contrast, positive affect is hypothesized to broaden the scope of attention and lead to more flexible cognition (e.g., Fredrickson, 1998; Isen, 1999). For example, positive affect increases sensory processing of irrelevant peripheral information relative to neutral and negative affect (Schmitz, De Rosa, & Anderson, 2009; Vanlessen, Rossi, De Raedt, & Pourtois, 2013). Positive moods also induce a global bias in visual judgments, while negative moods have the opposite effect, by narrowing focus to local details (Fredrickson & Branigan, 2005; Gasper & Clore, 2002). Affect can also influence memory performance: Positive affect tends to facilitate a more relational processing style during memory encoding, such that individuals in positive moods show increased false memory for semantically-related lures compared to individuals in negative moods (Emery, Hess, & Elliot, 2012; Storbeck & Clore, 2005, 2011).

These differences in the breadth of attention and memory under positive versus more negative affective states may be a result of variations in inhibitory control, with positive affect reducing and negative affect sharpening inhibitory control abilities (e.g., Rowe et al., 2007). In support of this idea, inducing positive affect in younger adults is known to increase interference from distractors relative to neutral and negative affect on a range of attention tasks, including flanker (Fenske & Eastwood, 2003; Rowe et al., 2007), Stroop (Phillips et al., 2002), set shifting (Dreisbach & Goschke, 2004), and negative affective priming (Goeleven, De Raedt, & Koster,
2007) tasks. In addition, while negative and neutral affect are associated with effective suppression of no-longer-relevant information, positive affect eliminates this directed forgetting effect (Bäuml & Kuhbandner, 2009). Finally, positive affect produces downstream effects of distractibility similar to those observed among older adults (Biss et al., 2010; Biss & Hasher, 2011). In two studies based on the paradigm used in older adults by Rowe and colleagues (2006), distracting words were presented in a 1-back task similar to the one used here, and priming for the distraction was tested using a word fragment completion test after a 10-minute delay. The results indicated that younger adults in both naturally-occurring (Biss et al., 2010) and experimentally-induced (Biss & Hasher, 2011) positive moods had enhanced priming for the distraction from the 1-back task compared to those under neutral affect conditions. Thus, like aging, positive affect appears to increase the influence of irrelevant information on behaviour, by relaxing inhibitory control over the contents of working memory and boosting implicit memory for distraction. In contrast, neutral and negative affect appear to sustain and even enhance younger adults’ inhibitory control over distraction.

Study 4

The question addressed here was whether the benefits of distraction as rehearsal observed among older adults in Studies 1a, 2, and 3b would also be seen for younger adults under positive affect conditions, and whether neutral affect might actually heighten younger adults’ suppression of items that occurred as distraction. To this end, a new set of younger participants completed a mood induction version of the indirect instruction condition of Study 3a. As before, participants studied and recalled a list of words initially and on a surprise, final recall test (see Figure 1). The 1-back task occurred in the middle of the retention interval and required a key press on every
trial to provide a measure of distractibility during this task. To assess the influence of mood on the ability to benefit from distraction as rehearsal, a positive or neutral mood was induced immediately prior to the 1-back task, using a 6-min mood induction procedure that has been successfully used in previous studies (Biss & Hasher, 2011; Biss, Weeks, & Hasher, 2012).

Given evidence of mood’s influence on distraction regulation (Biss & Hasher, 2011; Fredrickson & Branigan, 2005; Rowe et al., 2007; Schmitz et al., 2009; Vanlessen et al., 2013), I anticipated that younger adults in induced positive moods would show reduced forgetting of repeated words. I predicted that those in neutral moods would suppress the distracting words and thus might even show a memory cost for these items. That is, enhanced inhibition of distracting information under neutral affect (e.g., Bäuml & Kuhbandner, 2009; Rowe et al., 2007) could actually exacerbate forgetting of words from the original memory list that were reexposed as distraction in the 1-back task. Heightened forgetting of suppressed, repeated words might be predicted based on prior evidence that younger adults can inhibit irrelevant information to the extent that it is subsequently less accessible in memory (Healey, Campbell, Hasher, & Ossher, 2010; Healey et al., 2014; May & Hasher, 1998).

Method

Participants

Sixty younger adults (age range 18-23 years; 12 male, 48 female) were recruited using the same criteria as in previous studies. Thirty participants were randomly assigned to the neutral mood induction condition, and 30 were assigned to the positive mood condition. Eight participants (six in the neutral and two in the positive mood group) were aware that list words had repeated as distraction and reported consciously using or avoiding these items, and their data were replaced with that of new participants. Three additional participants were replaced: Two
participants (one neutral, one positive) had poor performance on the 1-back task (more than 2.5 SDs lower than their group mean), and one in the positive mood group rated her mood as extremely negative following the mood induction (more than 2.5 SDs below the mean rating in the positive mood group).

Age did not differ between younger adults assigned to the neutral ($M = 18.6$ years, $SD = 0.9$) and positive ($M = 18.9$ years, $SD = 1.4$) mood groups, $t < 1$. There was also no difference between neutral ($M = 12.7$, $SD = 1.0$) and positive ($M = 13.1$, $SD = 1.2$) groups in terms of years of education, $t(58) = 1.60$, $p = .12$. Despite random assignment to mood groups, the neutral group ($M = 31.0$, $SD = 3.4$) had higher vocabulary scores than the positive group ($M = 29.0$, $SD = 2.3$), $t(58) = 2.50$, $p = .02$. To test whether this may have affected group differences in task performance, all analyses were rerun with vocabulary scores included as a covariate. This did not change the pattern of any of the results; therefore the original analyses, without covariates, are reported.

**Materials**

The materials used for the initial and final recall and 1-back tasks were the same as those used in Study 3a.

Individual differences in affective state were measured using the brief mood introspection scale (BMIS; Mayer & Gaschke, 1988), which requires participants to rate the extent to which they currently feel each of 16 mood adjectives on a seven-point response scale. Scores were calculated on a positive affect dimension (items ranging from active and peppy to tired and drowsy) and a negative affect dimension (items ranging from jittery and nervous to calm). Brief mood ratings were also made throughout the study in order to establish the effectiveness of the mood induction and to check for any residual mood effects. Mood pleasantness was assessed
using a nine-point scale that ranged from 1 (not at all pleasant) to 9 (extremely pleasant). Arousal was also assessed, using a scale that ranged from 1 (very calm) to 9 (very aroused).

For the mood induction, 144 pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) using the published IAPS norms. Pictures were chosen for use in the neutral mood induction if valence ratings were between 4.5 and 5.5 on a 9-point scale ($M = 5.1, SD = 0.3$). Pictures for use in the positive mood induction were selected if valence ratings were greater than seven ($M = 7.5, SD = 0.4$). Pictures in both conditions had moderate arousal ratings (between 3 and 7 on a 9-point scale), and arousal ratings did not differ between neutral ($M = 4.2, SD = 0.9$) and positive pictures ($M = 4.4, SD = 0.6$), $t(121) = 1.40, p = .16$. All pictures were carefully selected to have no overlapping content with the critical memory list words.

Sound clips free of verbal material were also selected for use in the mood induction. In the neutral condition, participants listened to ambient street noise (BBC Sound Effects Library, 1986, tracks 23 & 28), while in the positive mood condition, participants listened to a jazzed up version of Bach’s (1721/1971, track 4) Brandenburg Concerto No. 3, which has been successfully used in previous studies to induce positive mood (e.g., Biss & Hasher, 2011; Rowe et al., 2007).

Procedure

Participants completed the BMIS before the experimental tasks began. Following procedures used in Study 3a, participants first studied and recalled the 20-word list, and the surprise final recall was tested following a 15-min retention interval. The mood induction procedure occurred in place of the first nonverbal filler task, that is, immediately before the 1-back task. The mood induction in each condition lasted six minutes: Participants were instructed
to relax and think about the pictures and sounds while they viewed the IAPS pictures on the computer screen and listened to the corresponding sound clip using headphones. The pictures appeared individually for five seconds each. The experimenter left the room while the participant completed the mood induction. Participants completed the 1-back task immediately after this mood induction (i.e., in the middle of the 15-min delay), followed by a nonverbal filler task, and then the final recall test. Awareness was assessed after final recall, as in the previous experiments. Finally, as a mood reinstatement at the end of the study, all participants were invited to watch a brief comedy video clip.

Brief mood pleasantness and arousal ratings were assessed on four occasions: at the beginning of the study (i.e., baseline), prior to the mood induction, following the mood induction (i.e., immediately before the 1-back task), and prior to the final recall test.

Results

Mood Ratings

Pre-existing mood state, as measured using the BMIS before the experiment began, was similar between the neutral and positive mood groups. Positive affect ratings did not differ between neutral ($M = 10.3, SD = 7.1$) and positive ($M = 11.2, SD = 7.1$) conditions, $t < 1$. Negative affect ratings also did not differ between the neutral ($M = 9.3, SD = 5.1$) and positive ($M = 8.9, SD = 5.9$) mood groups, $t < 1$.

Figure 6 shows mood pleasantness and arousal ratings made at different points in the study. Pleasantness ratings (see Figure 6A) were submitted to an ANOVA with mood group (positive, neutral) as a between-subjects factor and rating time (baseline, pre-induction, post-induction, final recall) as a within-subjects factor. Greenhouse-Geisser corrections for degrees of freedom are reported where appropriate. The main effect of mood group was not significant,
$F(1,58) = 3.24, p = .08$. There was a reliable main effect of rating time, $F(2.6,148.4) = 6.44, p < .001, \eta_p^2 = .10$, which was qualified by an interaction between mood group and rating time, $F(2.6,148.4) = 11.63, p < .001, \eta_p^2 = .17$.

![Figure 6](image)

*Figure 6.* Mean (A) mood pleasantness and (B) arousal ratings as a function of mood group (neutral vs. positive) and rating time (baseline, pre-induction, post-induction or prior to 1-back task, vs. final recall) in Study 4. Error bars represent standard errors of the means.

These mood pleasantness ratings were further explored using post-hoc t-tests with Bonferroni correction as implemented in SPSS 20. Following the mood induction, the positive group had more pleasant mood ratings compared to the neutral group, $p < .001$. There were no significant group differences in pleasantness ratings at any other times during the study, $ps = .99$. The positive mood induction successfully improved mood pleasantness relative to both baseline, $p = .03$, and pre-induction ratings, $p < .001$. The neutral mood induction was mildly negative: Pleasantness ratings made following the neutral induction were lower compared to baseline ratings, $p = .01$, but not significantly lower than pre-induction ratings, $p = .99$. 
Arousal ratings (see Figure 6B) were also submitted to a mixed ANOVA with mood group as a between subjects factor and time of rating as a within-subjects factor. There was a reliable main effect of rating time, $F(2.5,145.8) = 11.11, p < .001, \eta^2_p = .16$, with higher reported arousal towards the end of the study. There was no main effect of mood group or mood group by rating interaction, $Fs < 1$. Thus, the mood manipulation was effective at inducing group changes in mood pleasantness, while having little effect on arousal, and there were no mood differences between groups at the time of recall.

1-back Task Performance

Accuracy on the 1-back task was near ceiling and did not differ between the neutral ($Md\bar{n} = 98\%, M = 97\%, SD = 3\%$) and positive ($Md\bar{n} = 98\%, M = 97\%, SD = 3\%$) mood induction groups, $U = 383, z = 1.02, p = .31$. 1-back RTs for correct trials were trimmed by removing responses more than 2.5 SDs faster or slower than each participant’s cell mean (resulting in the removal of 1.2% of trials for neutral participants and 1.5% of trials for positive mood participants). These trimmed RTs (see Table 8 for means) were entered into a mood group x distractor type (nonword, repeated word, novel word) mixed ANOVA, with the latter variable examined within subjects. There was a main effect of distractor type: $F(2,116) = 3.78, p = .03, \eta^2_p = .06$. No other effects were significant, $Fs < 1$.

The main effect of distractor type was explored with post-hoc comparisons using Bonferroni corrections as implemented in SPSS 20. There was greater slowing on trials with a repeated word ($M = 514 \text{ ms}, SD = 75$) versus nonword distractor ($M = 500 \text{ ms}, SD = 72$), $p = .04$; however, there was no difference between trials with a novel word ($M = 507 \text{ ms}, SD = 71$) compared to a nonword distractor, $p = .56$. Similar to younger adults in Study 3a, RTs on trials with repeated words did not differ from trials with novel distractor words, $p = .39$. Thus, positive
and neutral mood induction groups performed similarly on the 1-back task, and this pattern in younger adults was again distinct from that observed among older adults in Study 3b, who were differentially slowed when a repeated word from the study list appeared as distraction.

Table 8.
Mean 1-back RT (ms) per trial by type of superimposed distractor in Study 4.

<table>
<thead>
<tr>
<th>Group</th>
<th>Nonword</th>
<th>Novel word</th>
<th>Repeated word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>499 (71)</td>
<td>500 (71)</td>
<td>510 (78)</td>
</tr>
<tr>
<td>Positive</td>
<td>502 (74)</td>
<td>513 (72)</td>
<td>517 (73)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.

Recall Performance

To determine the effect of induced mood on the use of distraction as a rehearsal opportunity, recall performance was analyzed using a mood (neutral, positive) x test time (initial, final) x word type (repeated as distraction, unrepeated) mixed ANOVA with mood group tested between-subjects, and test time and word type tested within-subjects (see Table 9 for means). There was a main effect of test time, $F(1,58) = 28.61, p < .001, \eta_p^2 = .33$, indicating overall forgetting between initial and final recall. The test time x word type interaction was not significant, $F < 1$, replicating the general finding from the previous experiments of similar forgetting for repeated and unrepeated items among younger adults. The 3-way interaction among mood, test time and word type was significant, $F(1,58) = 4.30, p = .04, \eta_p^2 = .07$. No other main effects or interactions reached significance, $Fs < 1$. 
Table 9.  
Percentage of words recalled at initial and final recall, and forgetting scores in Study 4.

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial Recall</th>
<th>Final Recall</th>
<th>Forgetting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unrepeated</td>
<td>Repeated</td>
<td>Unrepeated</td>
</tr>
<tr>
<td>Neutral</td>
<td>35 (17)</td>
<td>42 (15)</td>
<td>32 (18)</td>
</tr>
<tr>
<td>Positive</td>
<td>35 (21)</td>
<td>36 (18)</td>
<td>29 (17)</td>
</tr>
</tbody>
</table>

Note: Standard deviations appear in parentheses.

The 3-way interaction was unpacked with pairwise contrasts on forgetting scores (see Figure 7). In the positive mood group, forgetting did not differ between repeated and unrepeated words, \( t < 1 \). Thus, there was no evidence that induced positive mood allowed younger adults to benefit from distraction that could serve as a rehearsal opportunity, as it did for older adults. For individuals in the neutral mood condition, however, there was a difference between repeated and unrepeated word forgetting, \( t(29) = 2.90, p = .007, d = .53 \). Neutral mood individuals showed increased forgetting of words that had repeated as distraction relative to their forgetting of words that had not repeated. Forgetting of words that repeated as distraction was significantly elevated in the neutral compared to the positive mood group, \( t(58) = 2.41, p = .02, d = .62 \), while forgetting of unrepeated items did not differ across groups, \( t < 1 \).
Figure 7. Mean forgetting score (the percentage of words recalled in the initial test after study minus the percentage of words recalled after the delay) as a function of word type (repeated as distraction vs. unrepeated) and group (neutral mood vs. positive mood in Study 4 vs. younger adults under indirect retrieval instructions in Study 3a). Error bars represent 95% confidence intervals.

As is evident from Figure 7, both mood groups showed reliable forgetting of words that had repeated as distraction; however, as is apparent through examination of the error bars, which cross zero, forgetting of unrepeated words did not reach a .05 criterion for either mood group. These results indicate that younger adults did not benefit from distraction that could serve as a rehearsal opportunity, even when induced to be in a more positive mood. Furthermore, these findings suggest that words that had been repeated as distraction were less accessible at final recall for individuals in the neutral mood group.

As in the previous experiments, the rate of intrusions was compared between groups. The total number of intrusions did not differ between positive ($Mdn = 0, M = 1.03, SD = 1.65$) and neutral ($Mdn = 0, M = 0.57, SD = 1.07$) mood conditions, $U = 382, z = 1.17, p = .24$. These intrusions included very few distracting words from the 1-back task: Only two participants in the
positive mood condition and one participant in the neutral condition produced a single filler
distracting word in their final recall.

Discussion

Existing evidence indicates that younger adults in positive moods show enhanced priming
for previous distraction (Biss et al., 2010; Biss & Hasher, 2011)—a downstream benefit of
distractibility that parallels what has been observed in older adults (Rowe et al., 2006). Here, it
was predicted that inducing a positive mood in younger adults before they were exposed to
repeated studied words presented as distraction would reduce their forgetting of these items, in a
manner similar to that observed for older adults in the previous studies. However, younger adults
in the positive mood induction condition did not show this effect: Their forgetting of repeated
and unrepeated words did not differ. In this experiment, the positive mood group also showed no
evidence of greater distractibility on any measures of 1-back task performance. Accuracy on this
task approached ceiling, which may have obscured any possible group differences (see Biss &
Hasher, 2011 for similar null findings on 1-back task accuracy). In addition, there was no effect
of mood on 1-back task RTs for trials with different types of distractors. Thus, it appears that
inducing positive affect in younger adults did not allow them to benefit from distraction that
provided an opportunity to rehearse previously studied words.

Instead, the locus of the effect in the present study appears to have been in the neutral
mood condition and reflected a greater cost for words that repeated as distraction. The neutral
mood group showed significantly more forgetting for repeated compared to unrepeated words,
and they had heightened forgetting of these words compared to the positive mood group. While
this finding may seem surprising, it is worth pointing out that in the indirect retrieval condition of
Study 3a, which was identical save for a filler task occurring in place of the mood induction,
younger adults showed numerically greater forgetting of repeated compared to unrepeated words (see Figure 7). The neutral mood induction, which actually lowered the mood of participants relative to baseline ratings, appears to have intensified this tendency, such that these participants showed reliably greater forgetting of repeated compared to unrepeated words.

What possible mechanisms might account for the reduced accessibility of words that repeated as distraction among younger adults in a neutral (or mildly negative) mood? One possibility is that younger adults in the neutral group may have suppressed the representation of these items during the 1-back task, rendering them less likely to be retrieved at the final test. Previous evidence demonstrates that younger adults (in unassessed moods) are capable of suppressing irrelevant information to the extent that it is less accessible after a delay, even relative to information never encountered in the experiment. For example, younger adults inhibit words that compete with a desired response, such that they are subsequently slower to name these competitors than novel, unrelated words (Healey et al., 2010, 2014). Younger adults also suppress disconfirmed, no-longer-relevant sentence endings to below baseline levels when tested at their optimal time of day (i.e., in the evening; May & Hasher, 1998). In a comparable manner, inhibition of words that are repeated as distraction in the 1-back task may decrease memory access, resulting in greater forgetting of these items and preferential recall of unrepeated words. Since group differences in mood pleasantness only occurred prior to the 1-back task, it is likely that mood most strongly influenced processing during this task.

The possibility that neutral mood individuals suppressed repeated items when they were presented as distraction would fit with previous evidence that negative and neutral affect enhance inhibitory mechanisms. For example, both negative and neutral moods narrow attention to filter out flanking distractors (Rowe et al., 2007), and intensify forgetting of no-longer-relevant word lists that individuals are instructed to forget (Bäuml & Kuhbandner, 2009) relative to positive
moods. An enhanced inhibitory control explanation would also be consistent with the idea that negative affect narrows the scope of attention, while positive affect broadens it (Derryberry & Tucker, 1994; Fredrickson, 1998). Thus, the explanation that neutral affect enhanced suppression of repeated words when they were presented in the 1-back task would be broadly consistent with previous work suggesting enhanced inhibitory control under negative moods.

An alternative explanation may be that younger adults in a neutral or negative mood did not suppress repeated words when they occurred as distraction in the 1-back task, but rather avoided these items during the final retrieval test. More specifically, neutral mood individuals may have overzealously rejected repeated words while monitoring the source of retrieved items (e.g., Johnson et al., 1993). For example, they may have identified the repeated items as having occurred more recently than the unrepeated items, and therefore rejected these items as unlikely to have been part of the original study list. However, as the effects of the mood induction dissipated so that ratings did not differ between mood groups at final recall, it is unlikely that mechanisms at retrieval fully explain the difference in forgetting across mood groups. Future research that includes a mood induction before final recall may help elucidate the relative contribution of mechanisms during repetition or retrieval to the reduced accessibility of repeated words under neutral or mildly negative affect.

In conclusion, inducing positive mood, a manipulation used elsewhere to increase younger adults’ processing of distraction (e.g., Biss & Hasher, 2011; Rowe et al., 2007), did not allow younger adults to take advantage of distraction that could serve as a rehearsal opportunity. Considering evidence elsewhere that older adults are typically in a better mood than younger adults (e.g., Carstensen et al., 2011; Mroczek & Kolarz, 1998; Stone, Schwartz, Broderick, & Deaton, 2010), these data could also be taken to suggest that mood is not the source of older adults’ unique ability to use distraction to reduce forgetting. Future work that includes a mood
manipulation tested in older adults would be required to ascertain this (although we have not been particularly successful in the past at boosting the moods of older adults, given their pre-existing cheerful state).

Among younger adults, neutral or mildly negative affect appears to have reduced the accessibility of items that had repeated as distraction, perhaps by enhancing inhibition of these items during the 1-back task or by causing individuals in the neutral group to reject repeated items at final recall. It is possible that younger adults may show an advantage under other manipulations associated with greater distractibility in younger adults, such as when tested at a nonoptimal time of day (May & Hasher, 1998; Rowe et al., 2006), or when more distractible subgroups of younger adults are tested, for example, those with lower working memory capacities (Conway, Cowan, & Bunting, 2001; Vogel et al., 2005). However, together with the results of the previous experiments, the evidence reported here suggests that, unlike their older counterparts, younger adults do not use distraction to rehearse studied information.
Chapter 5: General Discussion

Individuals encounter a broad range of information in their everyday environments, including distraction that is irrelevant and must be ignored in order to focus on the task at hand. What if this distraction could actually strengthen memory, and in particular help individuals who are prone to forgetting? The current set of studies examined this question in older adults, who are known to both be more susceptible to distraction (Hasher et al., 2007, 1999; Hasher & Zacks, 1988; Rabbitt, 1965) and show more forgetting on explicit recall tests (e.g., Balota et al., 2000; Grady & Craik, 2000; Zacks & Hasher, 2006) compared to younger adults. Given this age-related increase in distractibility, it seemed possible that repeating studied items as distraction between study and a delayed test could function as memory-strengthening rehearsals to reduce older adults’ forgetting. As younger adults show greater proficiency at ignoring distraction (Hasher et al., 2007, 1999; Hasher & Zacks, 1988) and unattended repetitions are considered ineffective for promoting memory (e.g., Craik & Watkins, 1973; Greene, 2008; Nickerson & Adams, 1979), I hypothesized that younger adults’ forgetting would generally be unaffected by whether studied words were repeated as distraction or not. The question of whether younger adults might be able to take advantage of distraction as rehearsals under certain circumstances was further probed by cueing them about the relevance of the distraction at retrieval (Study 3a) and by manipulating mood before the helpful distraction was presented (Study 4).

Consistently across three experiments (Studies 1a, 2, and 3b), older adults showed an advantage for studied words that repeated as distraction, regardless of the timing of the repetition (Studies 1a and 2), the version of the 1-back task used (Study 3b indirect condition), or whether they were explicitly instructed about the relevance of the repetitions (Study 3b direct condition). This advantage was tied to a strengthening of repeated words rather than a disruption for
unrepeated words, as demonstrated when forgetting was compared to a control condition in which no words repeated (Study 1b). While older adults elsewhere have been reported to produce more extralist intrusions than younger adults (e.g., Kahana et al., 2005), increased recall of repeated words occurred without a concomitant increase in erroneous recall of unstudied distractors. Most significantly, the use of distraction as a rehearsal device eliminated age differences in free recall performance: Across three studies, older adults’ final recall of repeated words was equal to that of younger adults. Given that age-equivalent recall is a rare finding in the cognitive aging literature, these findings may have important implications for the design of interventions to support memory as people age.

In contrast, younger adults did not benefit from distraction that could serve as a rehearsal opportunity: They showed reliable forgetting of words that repeated as distraction across all experiments. More specifically, younger adults showed equivalent forgetting of repeated and unrepeated words when they were unaware that study list words had been presented as distraction during the 1-back task (Study 1a, Study 2, Study 3a indirect condition). There were two exceptions to the general non-effect shown by younger adults: (1) when explicit retrieval instructions cued participants to the relevance of the distraction (Study 3a direct condition), and (2) when a neutral mood was induced prior to the 1-back task (Study 4). These effects went in opposite directions, with direct instructions increasing younger adults’ forgetting of unrepeated words, and neutral mood heightening forgetting of repeated words. Overall, however, repeating studied words as distraction did not boost younger adults’ memory for these items, suggesting that distraction is not an effective source of memory-strengthening rehearsals for younger adults.
Relation to Existing Work on Attention, Memory, and Aging

A key predictor of individual differences in higher cognitive functioning is the ability to deploy inhibitory control to restrict the entrance of distraction into working memory, and thereby maintain focus on the goals of the current task (Hasher et al., 2007, 1999; Kane et al., 2007; Vogel et al., 2005). As a group, younger adults are effective at engaging inhibitory mechanisms to ignore irrelevant information. For instance, functional neuroimaging measures indicate that younger adults show minimal encoding-related activity for distraction (Campbell, Grady, et al., 2012; Rees et al., 1999; Schmitz, Cheng, & de Rosa, 2010; Vogel et al., 2005), in some cases suppressing distractor processing below passive baseline levels (Gazzaley, Cooney, McEvoy, Knight, & D’Esposito, 2005). Behaviourally, the presence of visual distraction has a limited influence on younger adults’ cognitive performance across various tasks (e.g., Connelly et al., 1991; Lustig et al., 2006; Mack & Rock, 1998; Wühr & Frings, 2008). For example, even when concurrent distraction can aid performance by hinting towards the solution to a current problem, it has no effect on younger adults’ problem solving at a peak time of day (May, 1999). Evidence of younger adults’ ability to restrict encoding of distraction was also evident in Studies 3a and 4 reported here. Analysis of 1-back task RTs indicated that, while younger adults showed evidence of interference based on the whether distractors were words or nonwords, they were not differentially slowed by repeated compared to novel distracting words. This suggests that broader associative or significance-based processing of the distracting words—which might support incidental rehearsals of this information—did not occur.

Distraction is also known to have minimal downstream effects on younger adults’ cognitive performance. Younger adults’ recognition memory for former distractors is generally at chance (Butler & Klein, 2009; Hoffman et al., 2011; Rees et al., 1999). They show poor implicit memory for distraction (Gopie et al., 2011; Kim et al., 2007; Rowe et al., 2006), and the
tacit inclusion of past distraction has no effect on younger adults’ ability to learn words (Thomas & Hasher, 2012) or paired associates (Campbell et al., 2010). In some cases, however, they can be cued to explicitly retrieve past distraction when they have an opportunity to re-study the distraction (Thomas & Hasher, 2012), when given word fragment cues (Gopie et al., 2011; but see Amer, 2012), or when tested using extremely sensitive recognition tests (Hoffman et al., 2011).

In the experiments reported here, younger adults’ final recall was not affected by whether memory list words were repeated as distraction or not, at least when instructions were implicit. Evidence of differential recall of repeated and unrepeated words only emerged when younger adults were explicitly informed to use repetitions that occurred as distraction, and in fact, this hindered their recall by biasing retrieval away from unrepeated words. This finding suggests that younger adults possibly had some weak knowledge of which items occurred as distraction, which they could only access when directly instructed. This limited knowledge of distraction may have been enough to interfere with unrepeated word recall, perhaps in a manner similar to retrieval-induced forgetting (M. C. Anderson et al., 1994) or through disruption of natural retrieval strategies (e.g., Basden & Basden, 1995). However, younger adults evidently restricted their encoding of distraction, such that it was insufficient to support precise strengthening of memory list words. Even a positive mood induction intended to broaden younger adults’ attention towards distraction did not produce a benefit for repeated words; the neutral mood induction may instead have sharpened younger adults’ ability to suppress distraction, such that repeated words were less accessible at final recall. Together with previous work, these studies indicate that younger adults’ limited processing of distraction appears insufficient to support memory-strengthening rehearsal, as is true for older adults.
In contrast, older adults’ mental lives appear to be more influenced by distraction, whether it is from the past or is currently present. The performance of older adults across the studies described here is consistent with the view that aging is associated with reduced overall efficiency of inhibitory control mechanisms, resulting in a more cluttered mental workspace in which irrelevant information, like distracting words in the 1-back task, can influence subsequent memory and behaviour (Hasher et al., 1999; Hasher & Zacks, 1988). In line with this perspective, greater costs of concurrent distraction on older adults’ performance were evident through their reduced 1-back task accuracy and greater slowing for repeated compared to novel distractors. The opportunity for distraction to serve as memory-strengthening rehearsals benefitted older adults’ final recall performance by diminishing forgetting of items that repeated as distraction, resulting in age-equivalent final recall of these items across three studies. This demonstrated benefit of age-related distractibility parallels previous demonstrations that older adults hold more tacit knowledge of past distraction (Campbell, Zimerman, et al., 2012; Kim et al., 2007; Rowe et al., 2006), and implicitly transfer this knowledge to benefit new learning on explicit recall tests (Campbell et al., 2010; Thomas & Hasher, 2012). These costs and benefits of increased distractibility in older adults are consistent with the predictions of inhibitory control theory (Hasher et al., 1999; Hasher & Zacks, 1988).

The benefit seen here for older adults is also consistent with evidence for sustained implicit retrieval as people age (e.g., La Voie & Light, 1994). Older adults demonstrated a mnemonic benefit for repeated words without their awareness during the 1-back task that rehearsal opportunities could occur. They also were unaware at the final recall test that using the distraction could aid their retrieval, and when instructed that this was the case in Study 3b, the benefit of distraction did not increase or decrease. Thus, older adults’ use of distraction as a
rehearsal device appears to rely on preserved implicit memory systems that tend to be resistant to the effects of aging.

An alternative explanation for these results is that improved recall of repeated words may reflect a source error or recollection failure in older adults. That is, at final retrieval, older adults may have incorrectly attributed features encoded as distraction as information from the study episode. This may be predicted by views that aging disrupts recollection (Jacoby et al., 2005; Jennings & Jacoby, 1997; Light, 2012) or source monitoring (Johnson et al., 1993; K. J. Mitchell & Johnson, 2009) processes, which help to differentiate between the origins of encoded information. According to these accounts, older adults may have been unable to use detailed source information to restrict their retrieval to information encoded during the original study episode. If older adults’ benefit for repeated items reflects a tendency to erroneously retrieve items from a wider range of sources (i.e., distraction from the 1-back task), one would predict they should additionally produce more extralist intrusions. However, older adults did not produce more intrusions from among the filler distractor words from the 1-back task or elsewhere in any of the experiments. Thus, it appears that recollective or source monitoring failures cannot solely account for these results. Older adults’ recall performance reflected a specific mnemonic boost for repeated items, rather than greater difficulty with selective retrieval of the original study list.

Potential Mechanisms of Memory-Strengthening by Distraction

Here, I have suggested that older adults’ greater attention to distracting items during the 1-back task accounts for the mnemonic boost observed for repeated items. What types of memory processes or mechanisms may have occurred during the 1-back task to produce this effect? To address this question, I turn to mechanisms that have been proposed to account for spaced repetition effects for target information.
One straightforward possibility is that, by virtue of being presented more often, repeated items received a greater quantity or quality of processing than unrepeated items. This explanation might be predicted by deficient processing accounts of spacing effects, which suggest that greater processing time (Shaughnessy, Zimmerman, & Underwood, 1972) and attention (Hintzman, 1974) are devoted to spaced repeated or rehearsed items. In particular, words that are repeated in a distributed manner receive more elaborative semantic processing (Challis, 1993). The possibility that repeated items benefit from increased semantic processing is supported by past evidence that older, but not younger adults show conceptual priming for previous distraction (Amer, 2012; Kim et al., 2007). As free recall is a retrieval task that benefits from conceptual processing (Blaxton, 1989; Roediger, 1990), additional meaning-based processing of repeated words when they were presented as distraction could have improved older adults’ final recall.

A second possibility is that older adults incidentally retrieved the original study episode when they saw the repeated study words. This idea would fit with study-phase retrieval accounts of spaced repetition effects, which suggest that repetitions cue retrieval of the original occurrence of an item, and thus, these items benefit from retrieval practice (Greene, 1989; Thios & D’Agostino, 1976). This may also be consistent with the proposal that repetitions cue spontaneous reminding of earlier presentations, and these recursive reminding episodes are themselves encoded to support later recollection (Hintzman, 2010). Given evidence that older adults involuntarily recognize (B. A. Anderson et al., 2011) and spontaneously rehearse (Healey et al., 2013) irrelevant information, older adults may generally be more likely to unintentionally retrieve past information when cued by items they attend to (including distraction) in the environment.

Contextual variability explanations have often been invoked in concert with study-phase retrieval explanations to explain spacing effects. These accounts suggest that each item in a
memory list is associated with a slowly drifting temporal context; repeated items benefit from additional retrieval cues because they have been encoded along with multiple contexts and item-item associations (Estes, 1955; Glenberg, 1979; Melton, 1970). Thus, a third possibility is that repeating items as distraction allowed older adults to encode repeated items with the additional contextual details present during the 1-back task, which could in turn serve as added retrieval cues at final recall. In addition, repeated items, having occurred more recently, would be associated with contextual information that was more similar to the contextual cues present at retrieval. One potential issue with this explanation is that it is unclear whether greater interference would be present when an item is associated with multiple contexts. As older adults are more susceptible to interference from competing associations than younger adults (e.g., Campbell et al., 2010; Gerard, Zacks, Hasher, & Radvansky, 1991; Kausler, 1994), any potential benefit could be obscured by interference caused by items being associated with multiple cues.

Recent theoretical accounts of spaced repetition emphasize that a combination of these mechanisms likely contribute to observed mnemonic benefits (e.g., Braun & Rubin, 1998; Greene, 2008; Polyn, Norman, & Kahana, 2009; Raaijmakers, 2003). Therefore, it is possible that increased processing, study-phase retrieval, and perhaps more varied contextual encoding of repeated words all contribute to older adults’ reduced forgetting of these items. As the current data cannot distinguish among these possibilities, future research is needed to elucidate the mechanisms underlying older adults’ mnemonic boost from repetitions presented as distraction.

Remaining Questions and Future Directions

There are several additional questions about these findings to be addressed by future research. One question is whether this type of procedure benefits older adults’ performance in more varied memory test conditions. In the studies reported here, participants were unaware of
the final, surprise recall test. Hence, future research is needed to explore whether older adults will continue to benefit from distraction if they are pre-warned about the delayed test at the outset of the experiment. It is also unknown whether similar effects would be seen on other retrieval tests, such as tests of recognition, cued recall, or prospective memory. Different mechanisms have been proposed to account for repetition effects on free recall, cued recall, and recognition tests (e.g., Glenberg, 1979; Greene, 1989), given that these tests rely to a different extent on factors such as item familiarity or contextual information. Thus, it is possible that the mnemonic benefits of distraction as repetition may vary according to the retrieval task used.

Many real-life memory slips for older adults reflect failures of prospective memory, or memory to perform a planned intention in the future (e.g., Henry, Macleod, Phillips, & Crawford, 2004). Thus, presenting distraction may also be a useful method to help older adults remember to perform future intentions. Demonstrating benefits on additional memory tests would expand the circumstances under which helpful distraction may improve older adults’ memory.

A second question relates to the generality of the benefits of distraction for older adults: Does an advantage for repeated items occur for all older adults, regardless of cognitive status, or do some older individuals disproportionately benefit? Individual differences in older adults’ attentional control abilities may predict the benefit from distraction as repetition, with more distractible older adults showing a larger advantage. In addition, older adults experiencing greater memory decline, such as those with mild cognitive impairment, may be more likely to profit from distraction as repetition if explicit memory impairments can allow implicit retrieval processes to come to the fore (Rowe, Troyer, Murphy, Hasher, & Biss, 2011). On the other hand, given that individual differences in automatic memory processes tend to be minimal (Hasher & Zacks, 1979), implicit retrieval of representations encoded during the 1-back task may occur for all older adults, regardless of cognitive status.
A final question is whether different conditions associated with increased distractibility in younger adults would be able to produce the benefit observed for older adults here. Inducing positive mood in younger adults was not successful at reducing their forgetting of repeated words. However, attentional control is also reduced among younger adults with lower working memory capacities (Conway et al., 2001; Vogel et al., 2005) and those tested at a nonoptimal time of day (May, 1999; Rowe et al., 2006). Thus, future work can examine whether distraction can serve as effective repetitions for these groups of younger individuals.

Applications for Distraction in Everyday Life

These findings have important implications for the design of practical applications to improve older adults’ memory functioning. While older adults appear to be less able to self-generate reflective forms of repetition, such as rehearsal (e.g., Ward & Maylor, 2005) or refreshing (Johnson et al., 2002), they do benefit from externally reinstated repetitions, that is, repeated study trials occurring as target information (e.g., Balota et al., 1989), or non-target distraction, as demonstrated here. Repeating to-be-remembered information as distraction may therefore improve memory function in older adults by outsourcing rehearsal opportunities to the environment. This idea is in line with evidence that age differences are minimized in situations that provide contextual support (Craik, 1986), as well as the idea that older adults can compensate for retrieval failures by using memory cues in the surrounding environment (Hasher & Zacks, 1988).

In the predictable environments encountered in daily life, this type of strategy is likely quite adaptive. Indeed, some older adults may spontaneously seize on these covert rehearsal opportunities during their everyday remembering. For example, glancing at a medication bottle visible on the kitchen table may remind an older adult to take a pill later on, even while he or she
is currently focused on an unrelated task, like making a sandwich. Successful use of non-target repetitions may help explain the absence of age differences that is sometimes reported when memory is tested in a familiar environment, such as when older adults show enhanced prospective memory performance at home, where environmental cues may serve as reminders (Henry et al., 2004). Although younger and older adults do not differ in the self-reported use of intentional reminders (Ihle, Schnitzspahn, Rendell, Luong, & Kliegel, 2012), the studies reported here suggest that older adults may reflexively make use of tacit repetitions that aid remembering outside of their awareness. Older adults with more severe memory impairments, including individuals with mild cognitive impairment and dementia due to Alzheimer’s disease, often have difficulty using memory compensation strategies (Dixon, Hopp, Cohen, de Frias, & Bäckman, 2003). These individuals may particularly benefit from the design of supportive environments and technologies that include non-target repetitions of important information, especially if these reminders can be implemented in novel, unfamiliar environments (e.g., when an individual moves in to a new long-term care facility).

The results reported here may inform the delivery of assistive technologies that provide external memory cues (Lindenberger, Lövdén, Schellenbach, Li, & Krüger, 2008). In particular, technology may be used to present helpful distraction: For example, covert reminders to attend a doctor’s appointment or to make a phone call could scroll across the screen as an older individual watches television or plays a game on a tablet. In many cases, noisy or cluttered displays full of distraction are disruptive for older adults, but not all distraction is necessarily problematic. Technology that minimizes bad distraction, like advertisements on a computer screen, and maximizes helpful distraction is likely to be most beneficial for older adults.
Conclusions

Repetitions or rehearsals occurring as goal-relevant, target information have long been known to improve memory (e.g., Crowder, 1976; Ebbinghaus, 1885/1964; Greene, 2008), and are generally associated with an equivalent benefit for younger and older adults (e.g., Balota et al., 1989; Cohen et al., 1987; Logan & Balota, 2008). The studies reported here indicate that older adults’ greater receptiveness to irrelevant information in the environment allows them to take advantage of an additional source of repetition that younger adults ignore. Using distraction as a rehearsal device capitalizes on older adults’ existing information processing style, in particular, their decreased inhibitory control (Hasher et al., 1999; Hasher & Zacks, 1988) and sustained implicit memory (La Voie & Light, 1994), to boost their memory performance. Given these unique benefits, it therefore may be promising for researchers and clinicians to work with older adults’ natural pattern of cognition to sustain memory, rather than trying to make older adults think and remember like younger adults.
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